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(54) **SNOWMOBILE COOLING SYSTEM**

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(73) Assignee: **BRP Finland Oy**, Rovaniemi (FI)

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B60K 11/00 (2006.01)

(52) **U.S. Cl.** **180/68.1**

(58) **Field of Classification Search** 180/68.1, 180/68.4, 190

See application file for complete search history.

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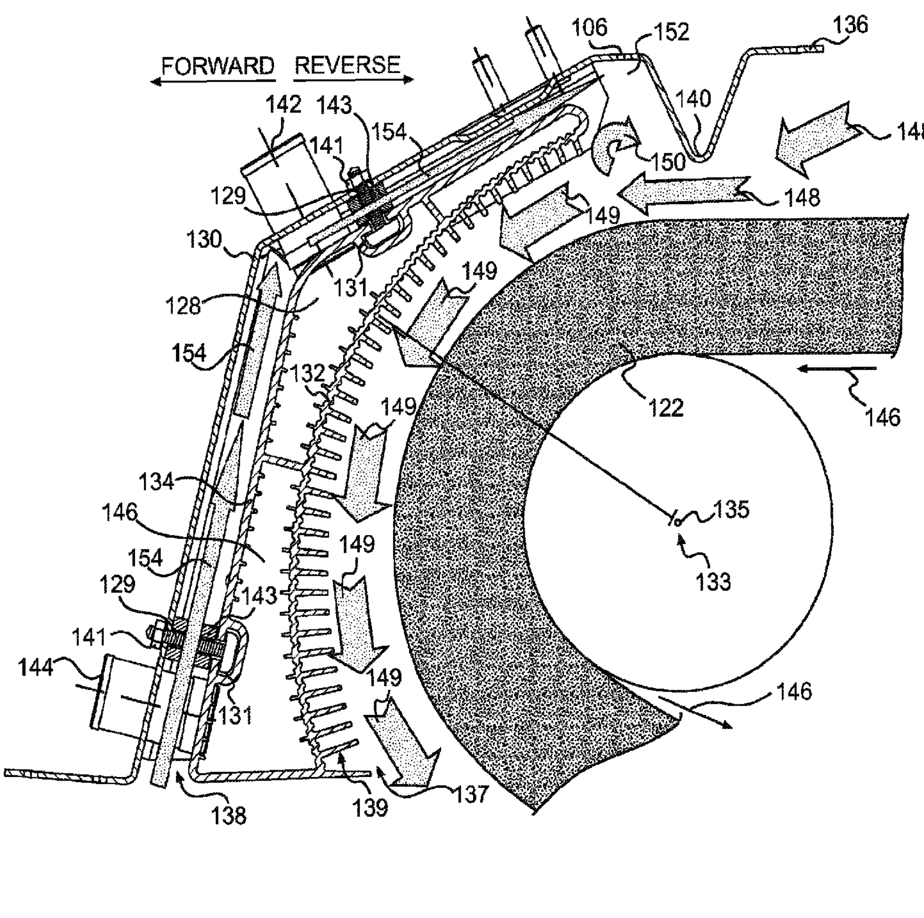
(57) **ABSTRACT**

A snowmobile is disclosed having a frame. A tunnel is formed in a rearward portion of the frame. An engine disposed on the frame. A drive track is disposed at least in part in the tunnel and is operatively connected to the engine for propulsion of the snowmobile. At least one ski is operatively connected to the frame at least in part forwardly of the drive track. A straddle seat is disposed on the frame at least in part above the drive track. A steering device is operatively connected to the at least one ski for steering the snowmobile. A radiator is disposed between the tunnel and the track. The radiator has a first side facing the track and a second side facing the tunnel. The second side is generally opposite the first side. At least a portion of the second side is spaced apart from the tunnel.

18 Claims, 13 Drawing Sheets



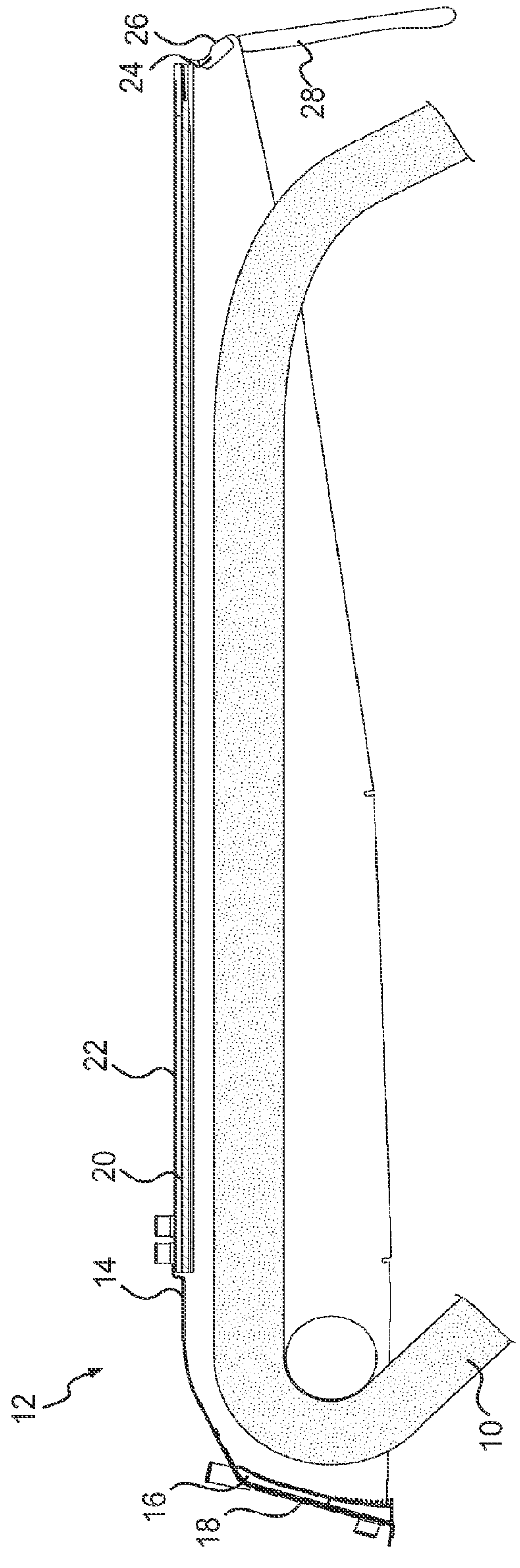


FIG. 1
PRIOR ART

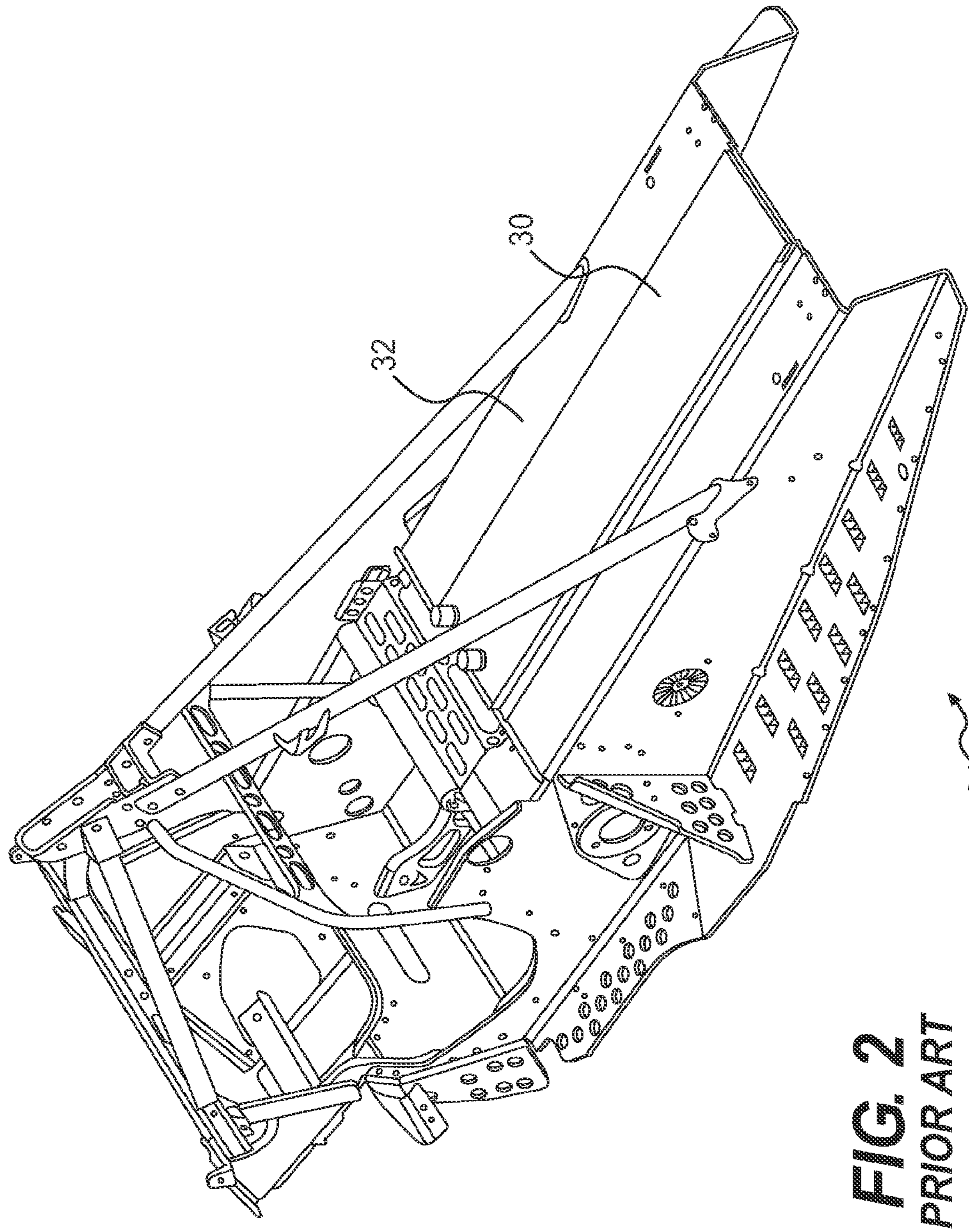


FIG. 2
PRIOR ART

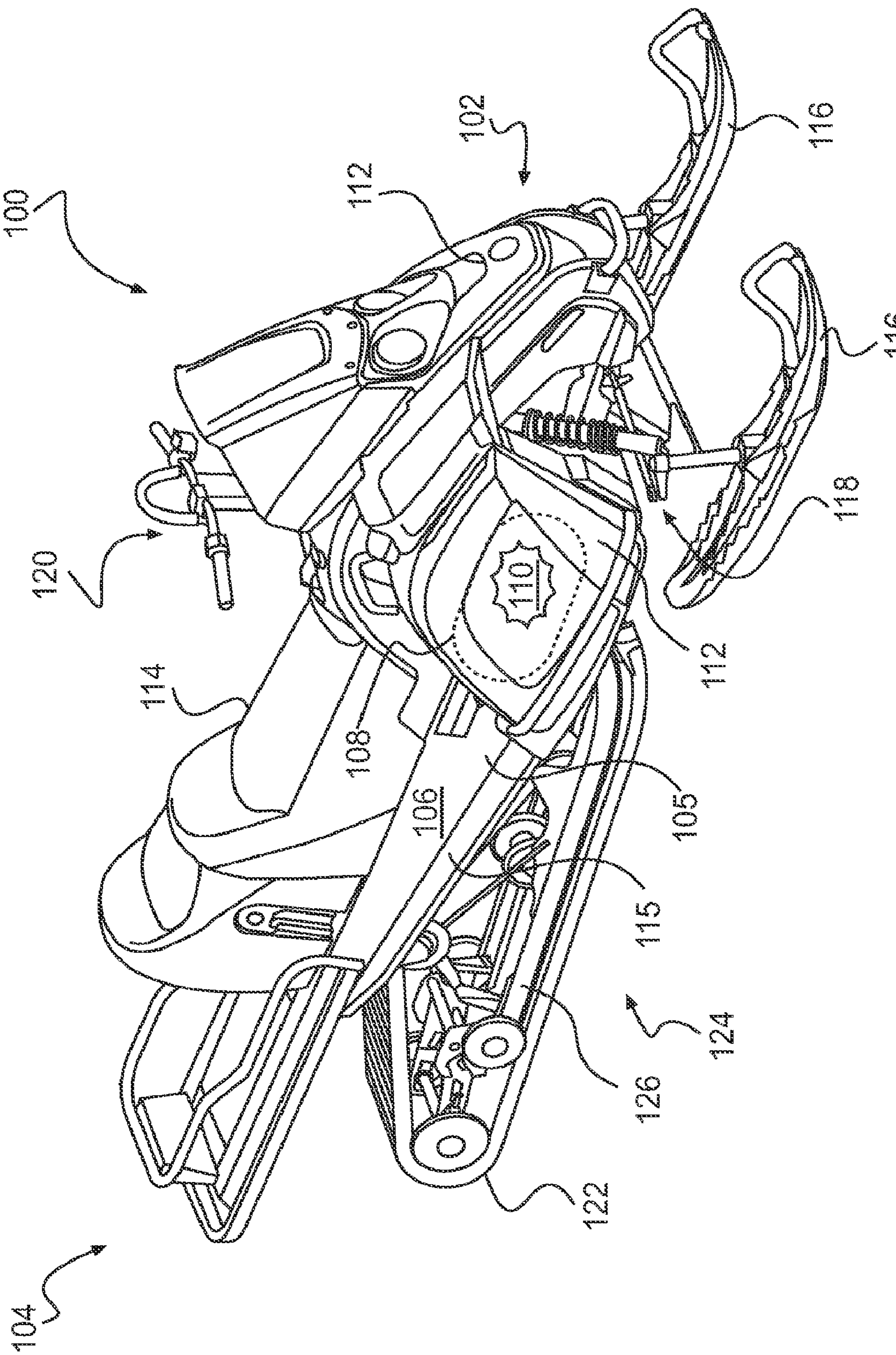
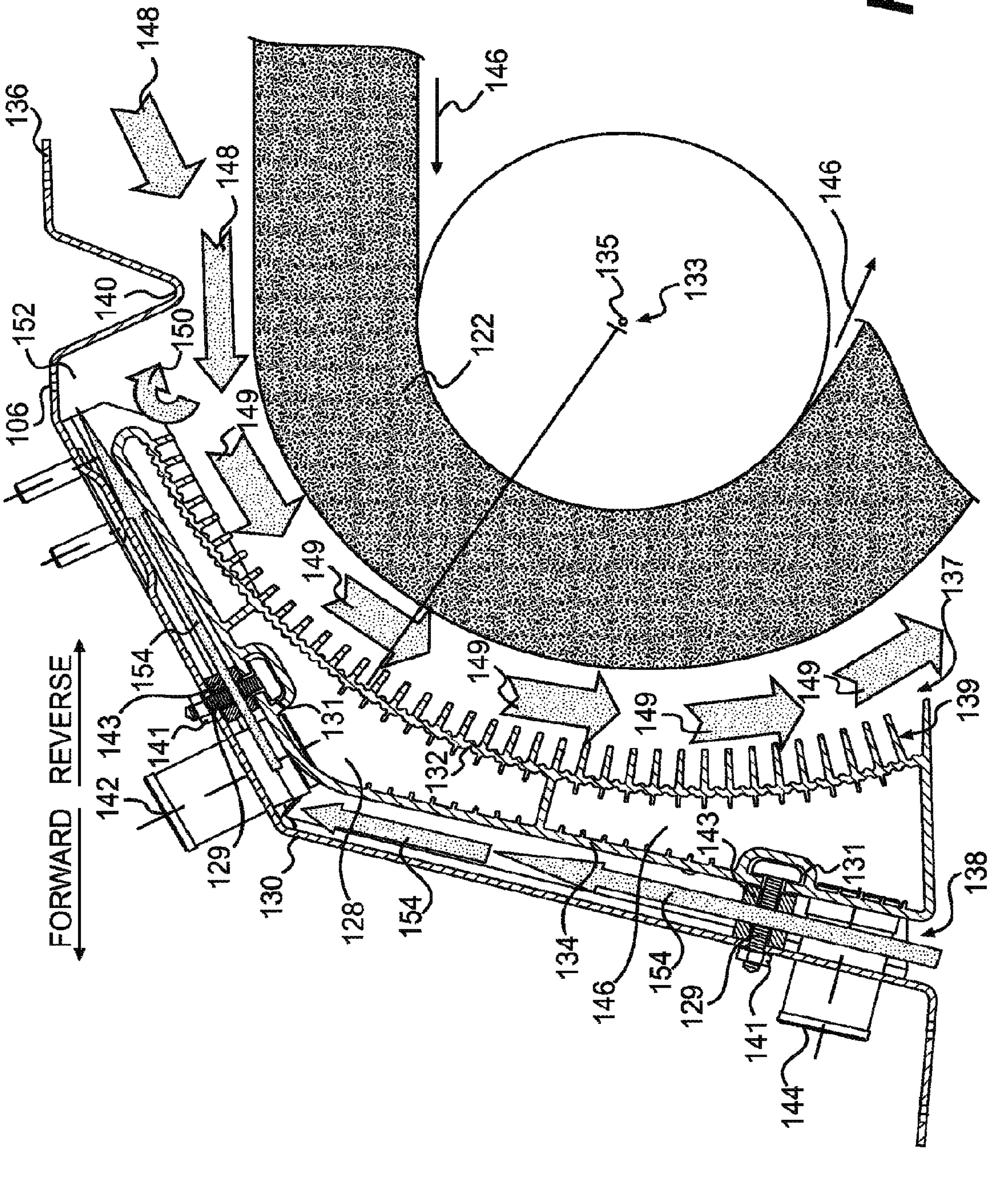

100
102
112
116
116
118
120
110
112
114
108
105
106
115
124
126
122
104

FIG. 3

FIG. 4


FORWARD
REVERSE
136
148
148
146
146
135
133
122
140
152
150
106
149
149
149
149
149
149
137
139
138
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142
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131
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131
154
129
141
144

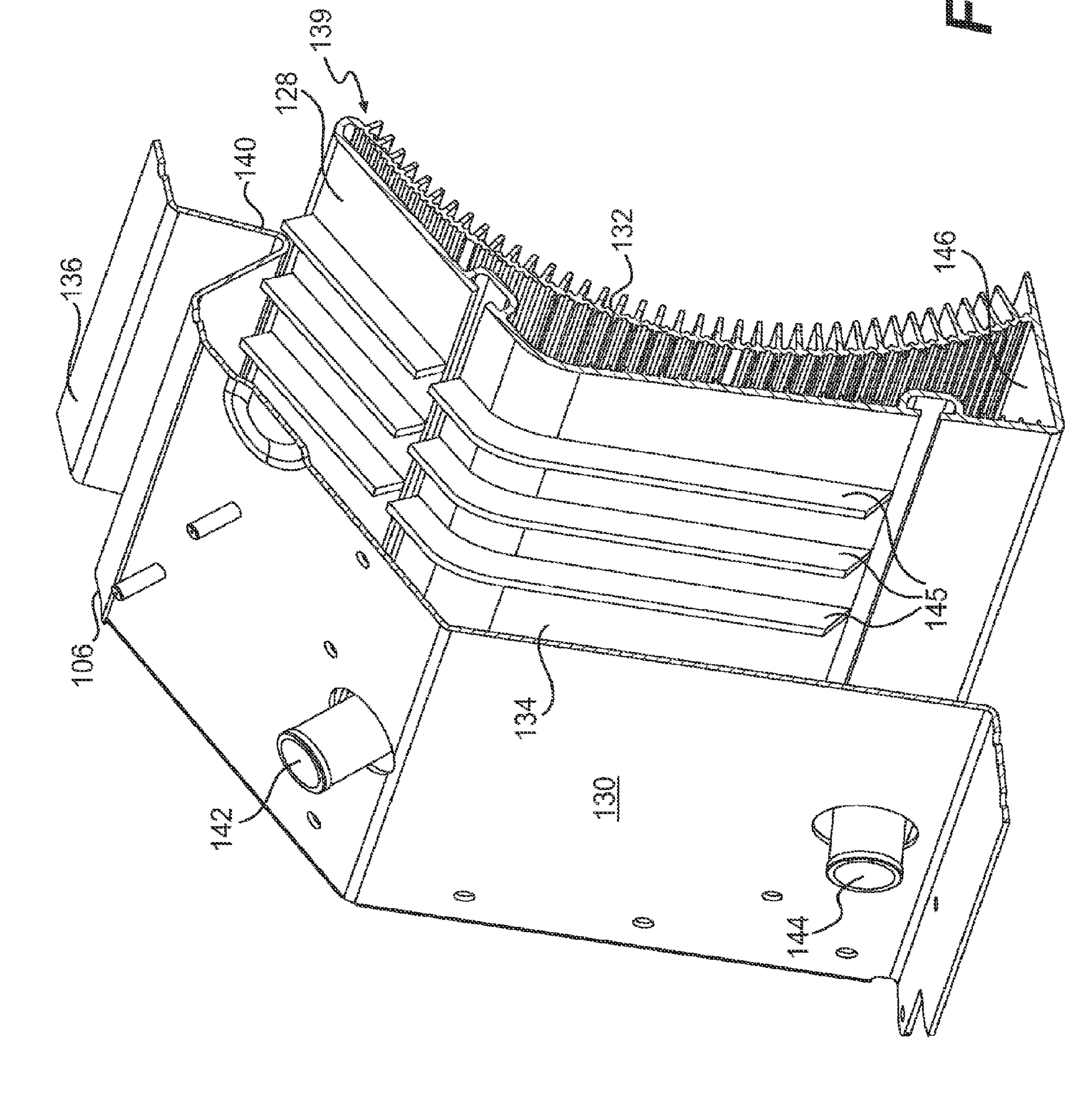

FIG. 5

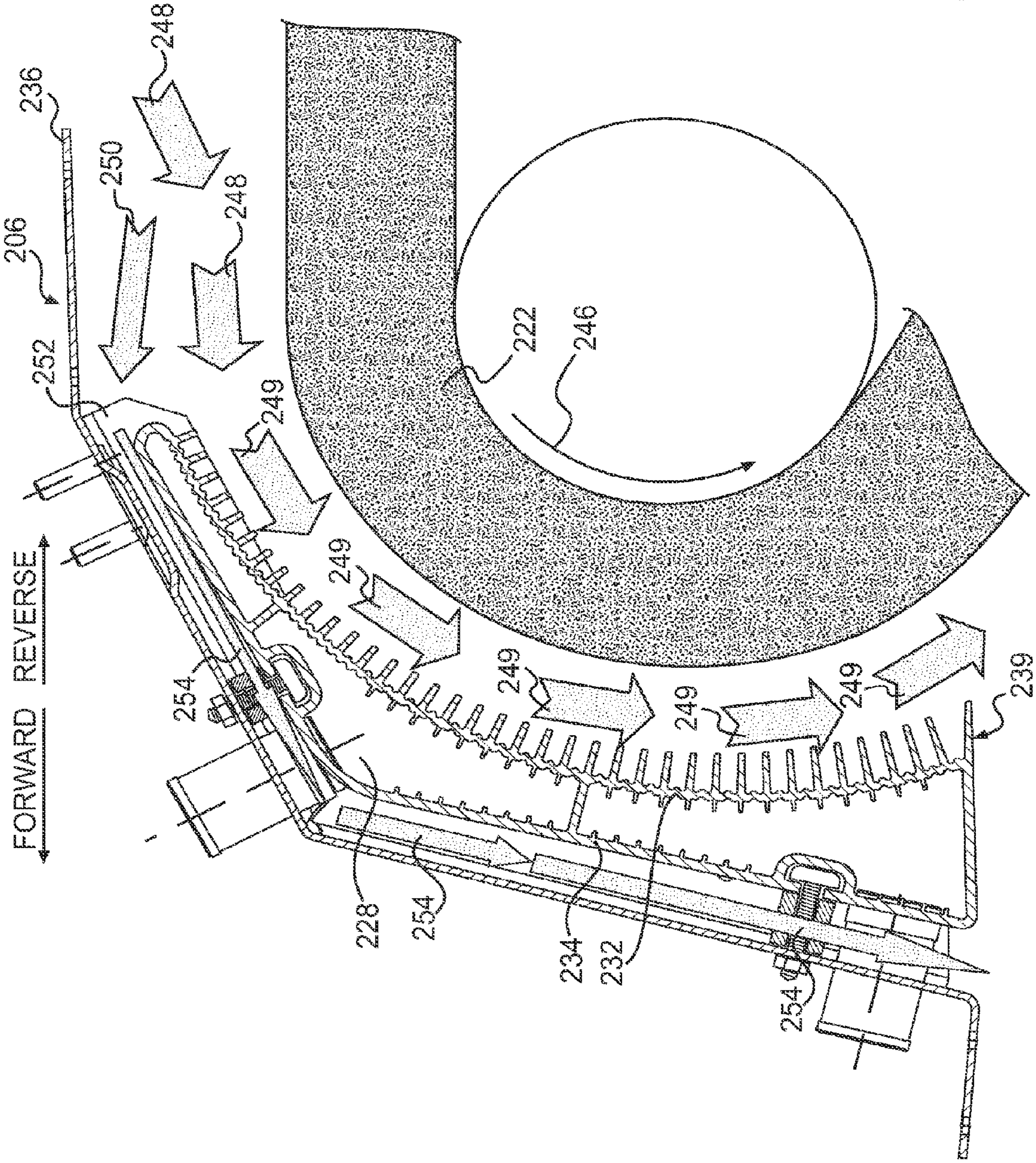
236
206
250
248
248
252
249
249
249
249
249
222
246
239
254
254
254
228
234
232
FORWARD
REVERSE

FIG. 6

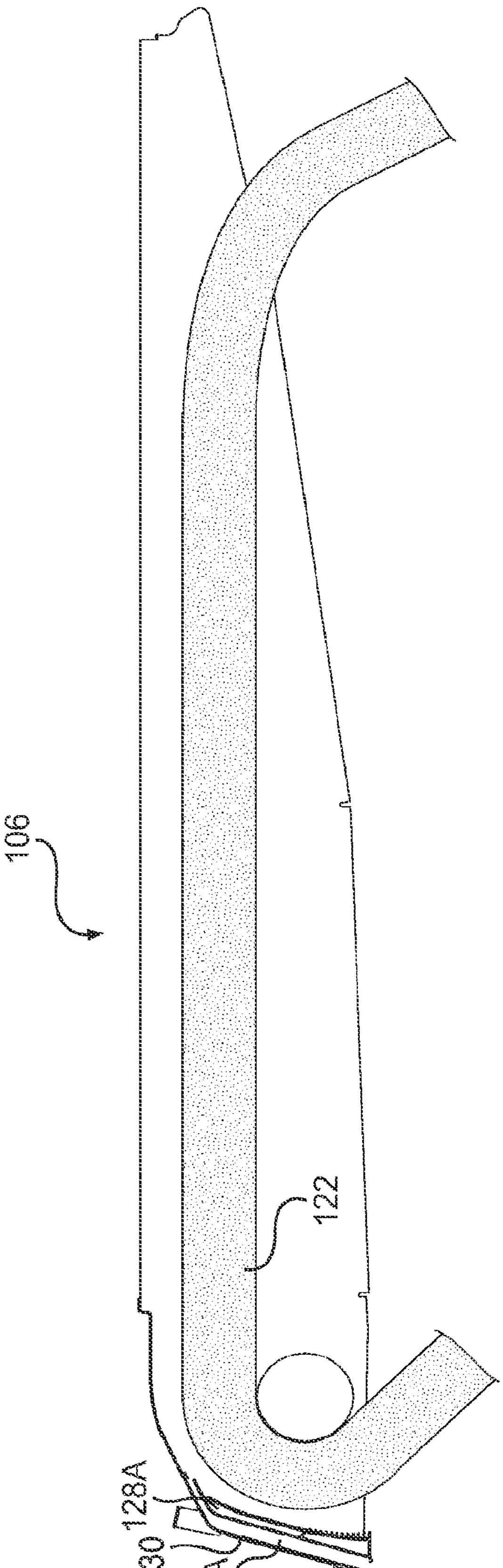

FIG. 7A

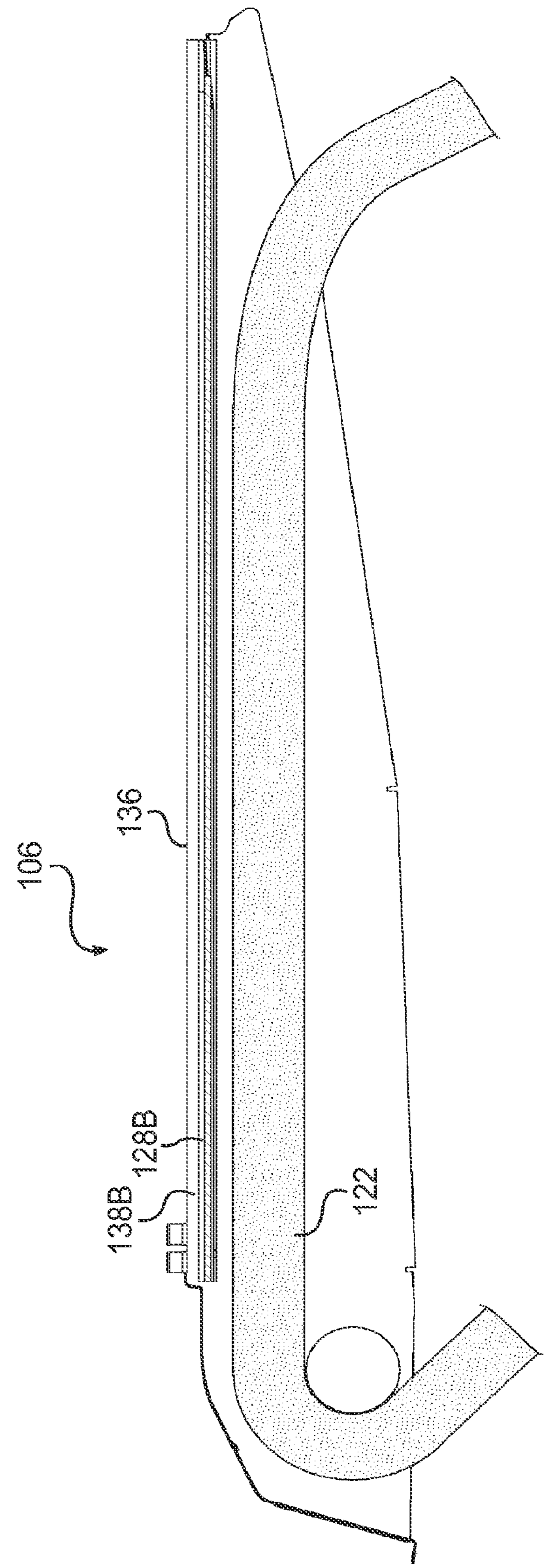

FIG. 7B

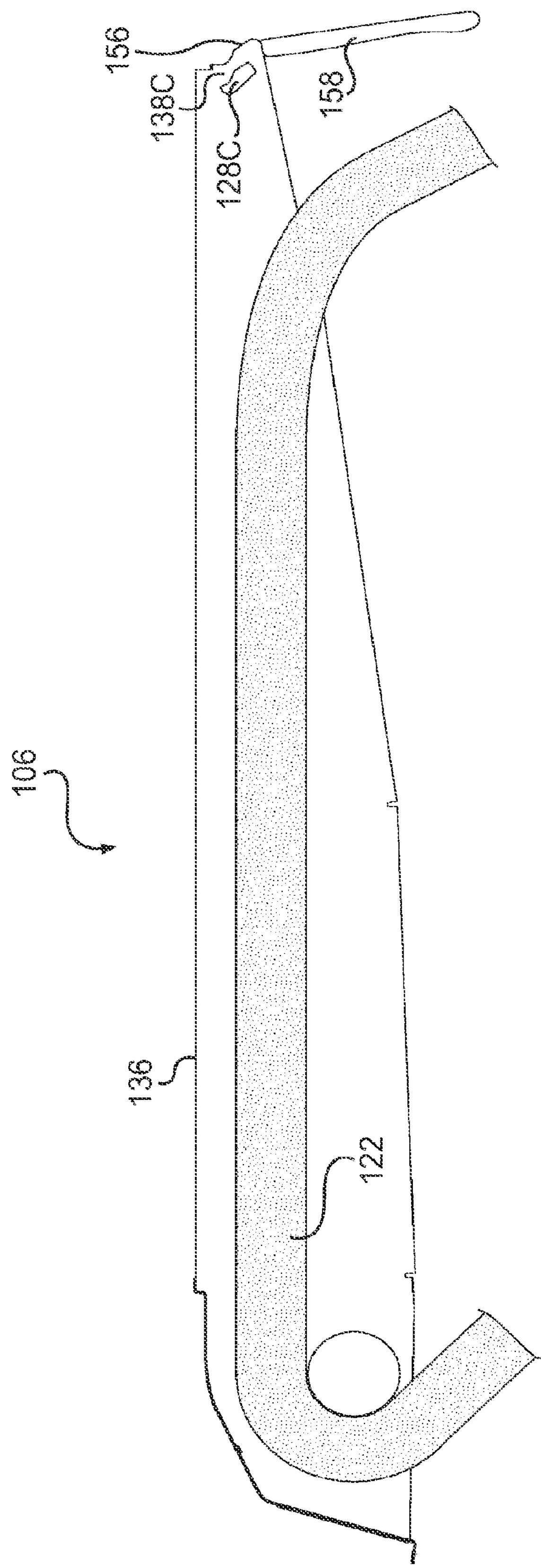

FIG. 7C

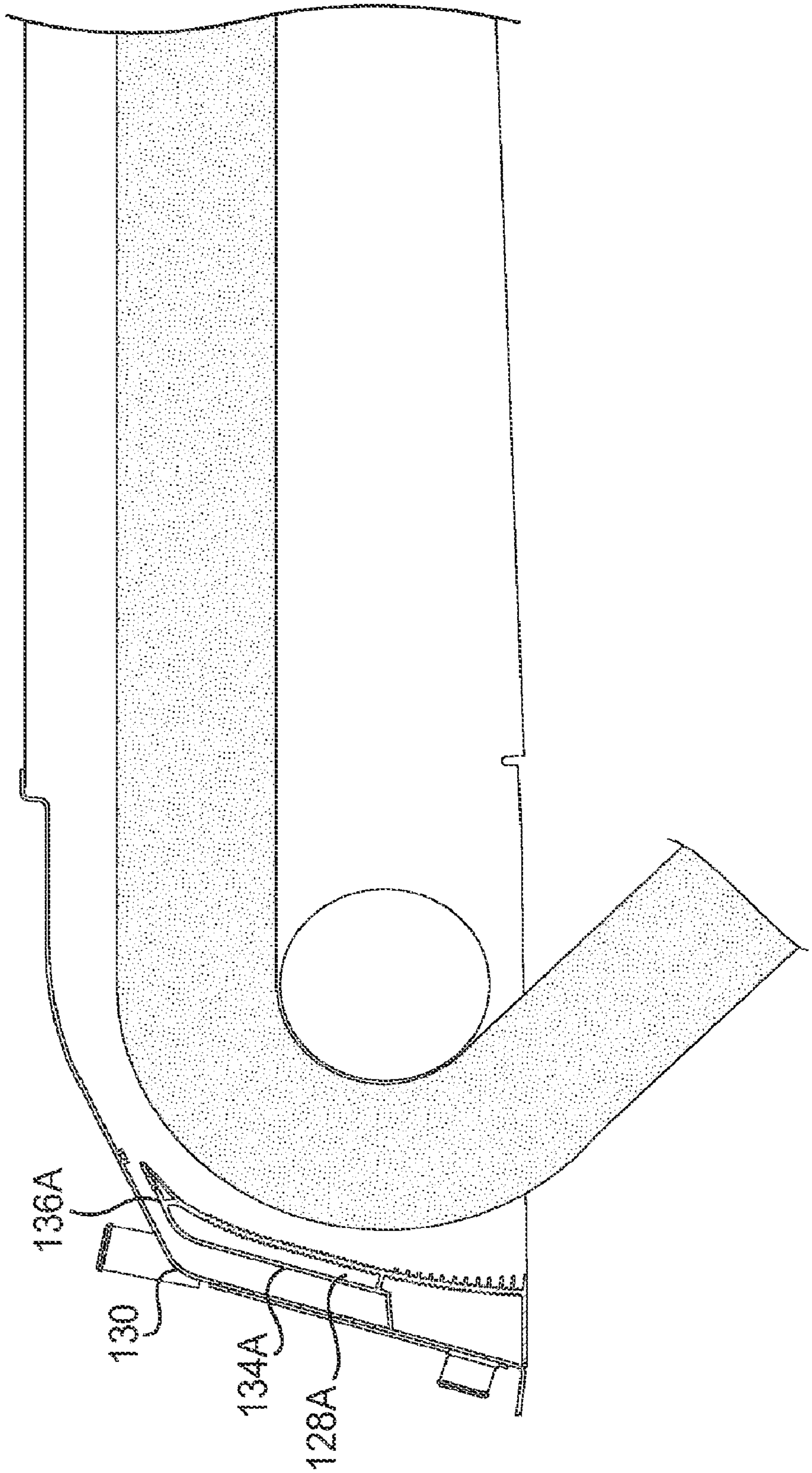

FIG. 8A

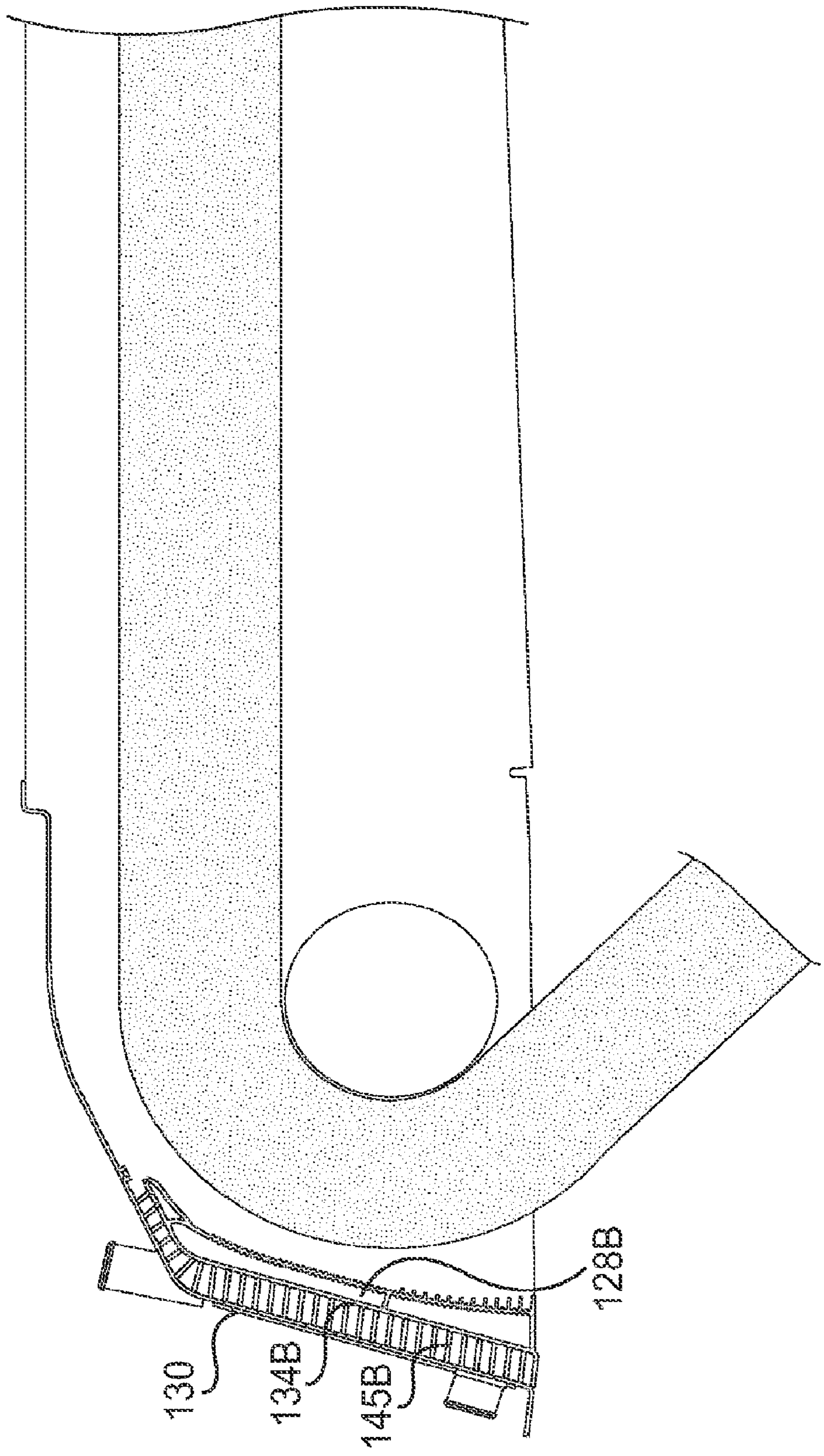

FIG. 8B

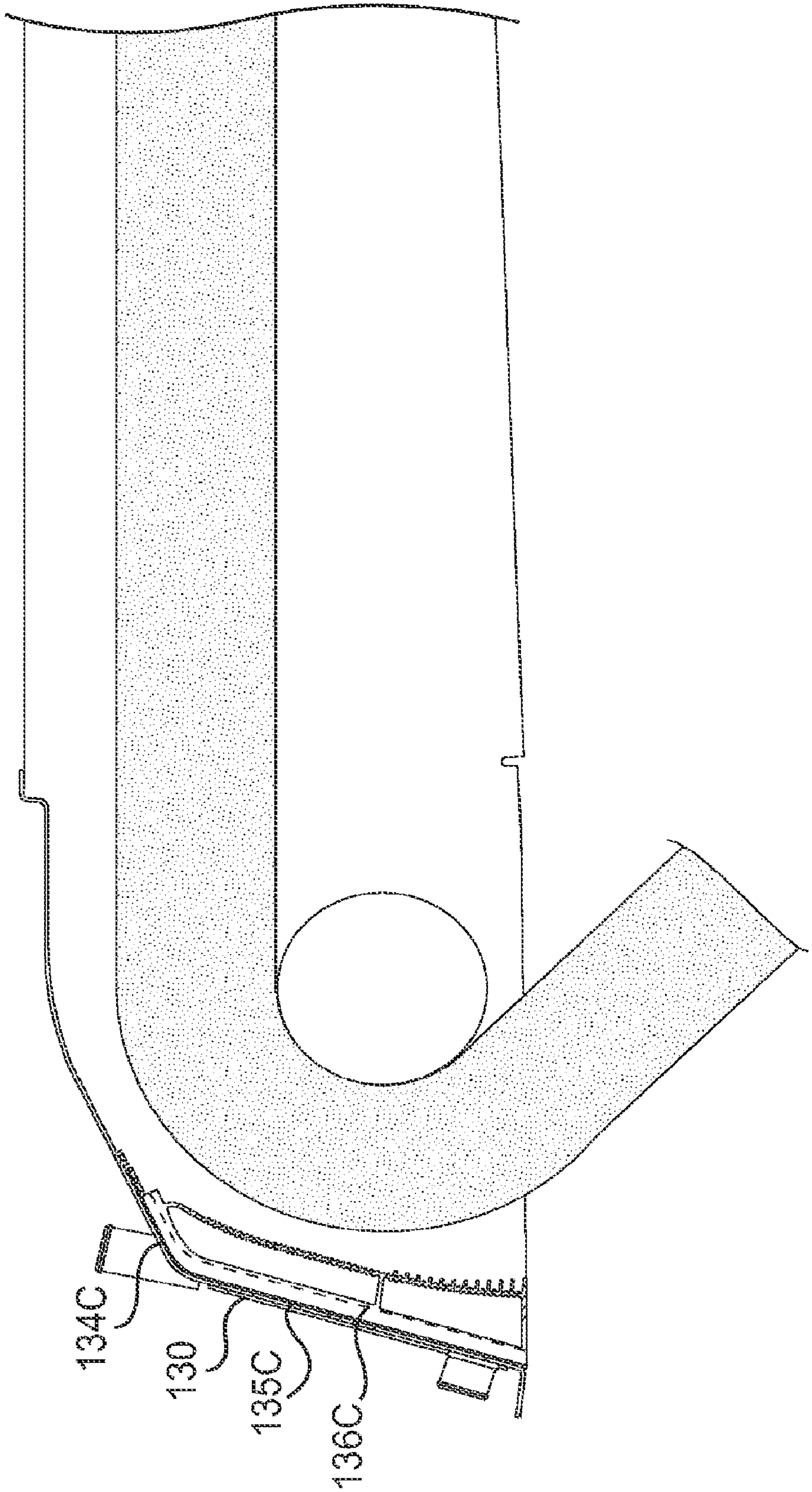

FIG. 8C

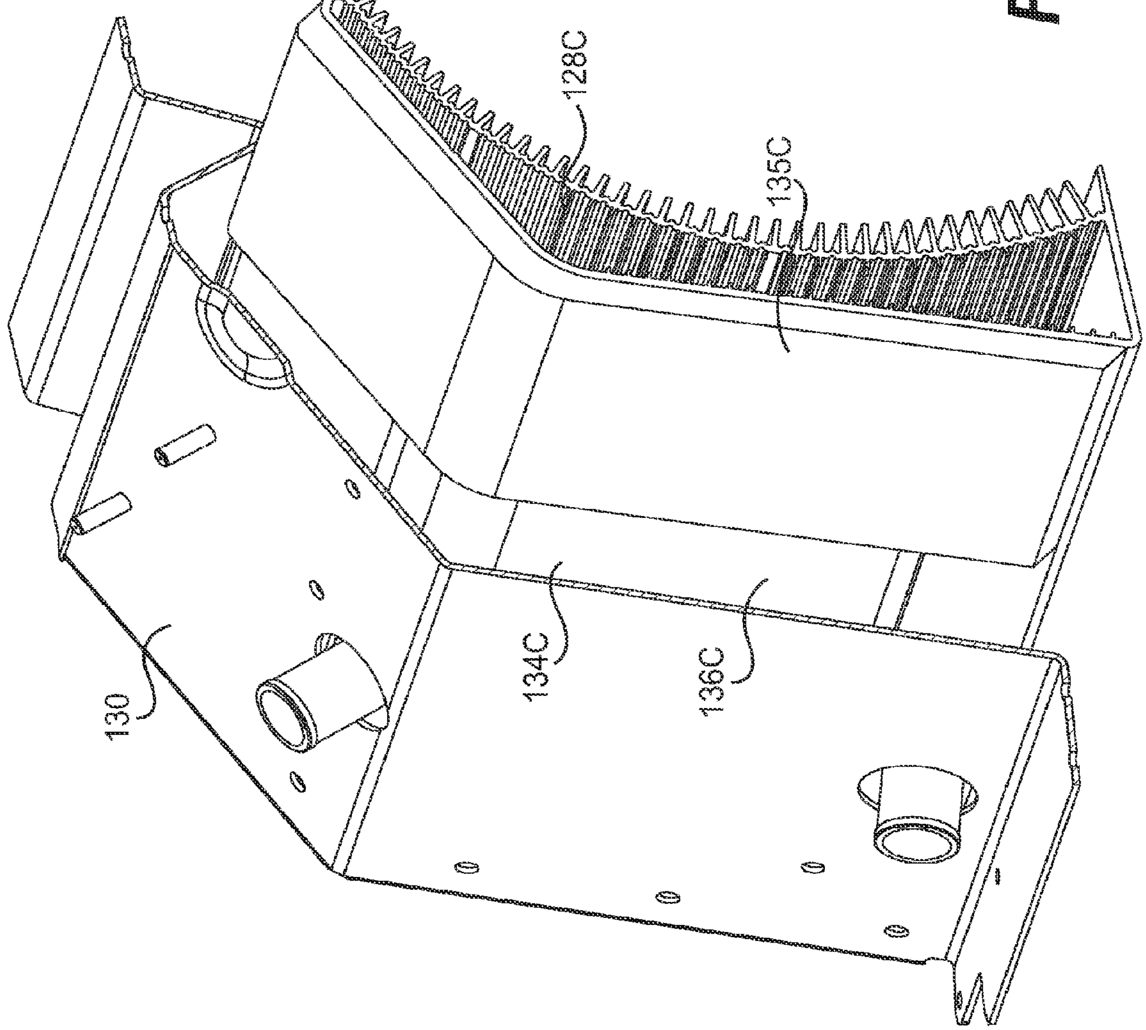

FIG. 8D

SNOWMOBILE COOLING SYSTEM

FIELD OF THE INVENTION

The present invention relates to a snowmobile cooling system.

BACKGROUND OF THE INVENTION

Most snowmobiles have a frame made of bent sheet metal and metal tubing. A forward portion of the frame forms an engine cradle for supporting an internal combustion engine. A rearward portion of the frame forms a tunnel generally having an inverted U-shape. A drive track is disposed at least in part in the tunnel and is driven by the engine to propel the snowmobile. The combustion of fuel in the engine produces a significant amount of heat, and some of this heat is absorbed from the engine by a coolant, such as a mixture of water and ethylene glycol, to maintain the engine at a suitable temperature. The hot coolant is then pumped to a radiator, where the heat is dissipated to the atmosphere.

Referring to FIG. **1**, during operation of a snowmobile, the rotation of the track **10** inside the tunnel **14** causes cold air and snow to circulate in the tunnel **14**. It is common to mount one or more radiators **16**, **20**, **24** at one or more positions on the inside of the tunnel **14**, facing the track **10**, so that the circulation of cold air and snow can be used to dissipate heat from the coolant flowing through the radiators **16**, **20**, **24** to cool the engine. The number of radiators and their size and positions within the tunnel **14** are dictated by the cooling requirements of the engine. The radiator **16** is positioned on the front wall **18** of the tunnel **14**, the radiator **20** is positioned on the top surface **22** of the tunnel **14**, and the radiator **24** is positioned on the inside of a rear portion **26** of the tunnel **14** in combination with a snow flap **28** to increase the quantity of snow that comes into contact with the radiator **24**.

Referring to FIG. **2**, in an alternative embodiment the radiator **30** may be constructed as part of the top surface **32** of the tunnel **34**, resulting in a reduced-weight snowmobile.

Although these arrangements provide adequate cooling for the engine of the snowmobile, they have a number of disadvantages.

When the radiator is positioned on the front wall of the tunnel, the metal frame conducts heat from the radiator to the engine compartment situated forwardly of the tunnel. As a result, the temperature of the engine compartment is increased, thereby reducing the effectiveness of the radiator to cool the engine.

Regardless of where the radiator is positioned on the tunnel, heat from the radiator is transferred to the tunnel. Snow coming into contact with the warm tunnel melts and later re-freezes, resulting in ice build-up on one or more of the tunnel, the track and the rear suspension assembly. The ice build-up increases the weight of the snowmobile. In addition, water that re-freezes on the track and rear suspension assembly when the snowmobile is not in use can in some cases result in the suspension or the track becoming jammed, making the snowmobile difficult to move.

In some snowmobiles, as described above, it is necessary to provide multiple radiators, to provide adequate cooling for the engine, resulting in increased weight of the snowmobile and increased cost of manufacture.

Therefore, there is a need for a snowmobile having a radiator arrangement that provides efficient cooling of the engine of the snowmobile.

There is also a need for a snowmobile having a radiator arrangement resulting in a lightweight cooling system.

There is also a need for a snowmobile having a radiator arrangement that reduces or eliminates the likelihood of ice build-up on the components of the snowmobile.

SUMMARY OF THE INVENTION

It is an object of the present invention to ameliorate at least some of the inconveniences present in the prior art.

It is also an object of the present invention to provide a radiator spaced apart from the frame of the snowmobile.

In one aspect, the invention provides a snowmobile comprising a frame. A tunnel is formed in a rearward portion of the frame. An engine is disposed on the frame. A drive track is disposed at least in part in the tunnel. The drive track is operatively connected to the engine for propulsion of the snowmobile. At least one ski is operatively connected to the frame at least in part forwardly of the drive track. A straddle seat is disposed on the frame at least in part above the drive track. A steering device is operatively connected to the at least one ski for steering the snowmobile. A radiator is disposed between the tunnel and the track. The radiator has a first side facing the track and a second side facing the tunnel. The second side is generally opposite the first side. At least a portion of the second side is spaced apart from the tunnel.

In a further aspect, at least 25% of the second side is spaced apart from the tunnel.

In a further aspect, at least 50% of the second side is spaced apart from the tunnel.

In a further aspect, at least 75% of the second side is spaced apart from the tunnel.

In a further aspect, the entire second side is spaced apart from the tunnel.

In a further aspect, an air passage is between the second side of the radiator and the tunnel.

In a further aspect, when the snowmobile is being operated in the forward direction, the direction of air flow along the first side is opposite the direction of air flow along the second side.

In a further aspect, the radiator is disposed at least in part forwardly of the track.

In a further aspect, the tunnel has a front wall. The second side of the radiator faces the front wall of the tunnel.

In a further aspect, the second side of the radiator generally follows a contour of the front wall of the tunnel.

In a further aspect, the top wall of the tunnel has a downwardly-extending projection disposed generally rearwardly of the air passage.

In a further aspect, when the snowmobile is being operated in a forward direction, an area of reduced air pressure is created at a rearward opening of the air passage.

In a further aspect, when the snowmobile is being operated in the forward direction, the direction of air flow along the first side is opposite the direction of air flow along the second side.

In a further aspect, the first side of the radiator is generally arcuate.

In a further aspect, the track is supported by a plurality of axles. One of the plurality of axles is a forwardmost axle. The first side of the radiator forms a generally circular arc having a center of curvature approximately at an axis of rotation of the forwardmost axle.

In a further aspect, the radiator has an inlet and an outlet. The inlet and the outlet communicate with an interior of the radiator via the second side. The inlet and the outlet pass through the front wall of the tunnel.

In a further aspect, the first side of the radiator has a plurality of fins projecting outwardly therefrom in the direction of the track. The second side of the radiator has generally flat sections.

In a further aspect, the first side of the radiator has a first plurality of fins projecting outwardly therefrom in the direction of the track. The second side of the radiator has a second plurality of fins projecting outwardly therefrom.

In a further aspect, the second plurality of fins contact the tunnel.

For purposes of this application, terms relating to spatial orientation, such as "forwardly", "rearwardly" and "transversely" are defined consistently with a forward travel direction of the snowmobile.

Embodiments of the present invention each have at least one of the above-mentioned objects and/or aspects, but do not necessarily have all of them. It should be understood that some aspects of the present invention that have resulted from attempting to attain the above-mentioned objects may not satisfy these objects and/or may satisfy other objects not specifically recited herein.

Additional and/or alternative features, aspects, and advantages of embodiments of the present invention will become apparent from the following description, the accompanying drawings, and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention, as well as other aspects and further features thereof, reference is made to the following description which is to be used in conjunction with the accompanying drawings, where:

FIG. **1** is a schematic cross-sectional view of a prior art snowmobile tunnel, taken along the longitudinal centerline of the tunnel;

FIG. **2** is a perspective view, taken from a rear, left side, of a prior art frame assembly for a snowmobile;

FIG. **3** is a perspective view, taken from a front, right side, of a snowmobile in accordance with aspects of the present invention;

FIG. **4** is a cross-sectional view of a front portion of the tunnel and radiator of the snowmobile of FIG. **3**, taken along the longitudinal centerline of the snowmobile of FIG. **3**;

FIG. **5** is a partial cut-away perspective view of the tunnel and radiator of FIG. **4**;

FIG. **6** is a cross-sectional view of a front portion of the tunnel and radiator of a snowmobile according to an alternative embodiment;

FIGS. **7**A-**7**C are schematic cross-sectional views of snowmobile tunnels, taken along the longitudinal centerline of the tunnel, showing various embodiments of radiator arrangements; and

FIGS. **8**A-**8**D illustrate various alternative embodiments of the radiator of the snowmobile of FIG. **3**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **3**, a snowmobile **100** will be described. The snowmobile **100** has a forward end **102** and a rearward end **104** which are defined consistently with a travel direction of the vehicle. The snowmobile **100** has a frame **105** including a tunnel **106** and an engine cradle **108**. The tunnel **106** generally consists of one or more pieces of sheet metal bent to form an inverted U-shape. The tunnel **106** extends rearwardly along the longitudinal centerline of the snowmobile **100** and is connected at the front to the engine cradle **108**. An engine **110** (schematically illustrated) is supported by the engine cradle **108**. A number of fairings **112** are supported on the frame **105** to provide aesthetic appeal and to shield some components of the snowmobile **100** from the elements. A straddle seat **114** is provided above the tunnel **106** for accommodating a rider and, optionally, one or more passengers. Footrests **115** extend outwardly from the tunnel **106** to support the feet of the rider and passengers.

A pair of skis **116** at the front end **102** of the snowmobile **100** are connected to the frame via a suspension system **118**. A steering assembly **120** is provided generally forwardly of the seat **114**, and is connected to the skis **116** in a known manner such that turning the steering assembly **120** turns the skis **116** to steer the snowmobile **100**. It should be understood that the snowmobile **100** may alternatively have only a single ski **116**.

At the rear end **104** of the snowmobile **100**, an endless track **122** is supported by a rear suspension system **124**. The rear suspension system **124** includes a pair of slide rails **126** in sliding contact with the track **122**. The upper portion of the track **122** is disposed in the tunnel **106**. The track **122** is driven by the engine **110** via a transmission (not shown) to propel the snowmobile **100**.

A cooling system circulates a liquid coolant through the engine **110** to absorb some of the heat generated by the combustion of fuel in the engine **110** and maintains the engine **110** at a suitable operating temperature. The coolant is then circulated to a radiator **128** (FIG. **4**) that will be described below in further detail, to dissipate the heat to the atmosphere.

Referring now to FIGS. **4** and **5**, the radiator **128** will be described.

The radiator **128** is mounted inside the tunnel **106**, between the front wall **130** of the tunnel **106** and the track **122**. The radiator **128** is held in position by fasteners **129** such as bolts inserted through the front wall **130** of the tunnel **106** and received in the recesses **131** of the radiator. Each fastener **129** is held in position by a corresponding nut **141**. A spacer **143** disposed on the fastener **129** maintains the second side **134** of the radiator **128** in a position spaced apart from the front wall **130**. A portion of the radiator **128** is disposed forwardly of the track **122**. It is contemplated that the entire radiator **128** may be disposed forwardly of the track **122**. A first side **132** of the radiator **128** faces a forward portion of the track **122**. The first side **132** is generally arcuate and forms a generally circular arc with its center of curvature approximately at the axis of rotation **133** of the forwardmost axle **135** supporting the track **122**, such that the first side **132** and the track **122** form an air passage **137** of approximately uniform width therebetween. A plurality of fins **139** extend outwardly from the first side **132**, generally in the direction of the track **122**, to provide increased thermal contact between the radiator **128** and the air passage **137**.

A second side **134** of the radiator **128**, generally opposite the first side **132**, faces the front wall **130** of the tunnel **106** and is spaced apart therefrom. The second side **134** generally follows the contour of the front wall **130**. An air passage **138** is formed in the space between the radiator **128** and the front wall **130** of the tunnel **106**. The air passage **138** reduces heat transfer from the radiator **128** to the tunnel **106** and thus reduces or eliminates the likelihood of ice build-up on the frame **105**. In addition, the flow of air **154** through the passage **138** contributes to cooling the second side **134** of the radiator **128** as will be discussed below in further detail. Other positions are contemplated for the radiator **128**, as will be described in further detail below. It is further contemplated that a thermally insulating material may be provided between the radiator **128** and the tunnel **106** instead of, or in addition to, the air passage **138** to reduce heat transfer to the tunnel **106**. The second side **134** is made of generally flat sections. It is contemplated that the second side **134** has fins **145** projecting outwardly therefrom The fins **145** are oriented generally parallel to the flow of air **154** along the second side **134**, so as not to interfere with the flow of air **154**. It is contemplated that the fins **145** may alternatively have a different orientation, for example the fins **145** may be oriented transversely. It is further contemplated that the fins **145** may extend far enough away from the second side **134** that they contact the front wall **130**, in which case the spacers **143** may be omitted. It is further contemplated that the second side **134** may alternatively be formed of flat sections only, without the fins **145**.

A downwardly-extending projection is formed in the top wall **136** of the tunnel **106**, generally rearwardly of both the radiator **128** and the air passage **138**. The projection **140** prevents snow or other debris from being thrown by the track **122** into the air passage **138** and obstructing the air flow therethrough. The projection **140** additionally creates an upward flow of air **154** (FIG. **4**) through the air passage **138**, as will be described below in further detail.

An inlet **142** and an outlet **144** of the radiator **128** pass through apertures in the front wall **130** of the tunnel **106** and allow the cooling system of the engine **110** to communicate with the interior **146** of the radiator **128** via the second side **134** of the radiator **128**. Hot coolant from the engine **110** enters the interior **146** of the radiator **128** via the inlet **142** and returns to the engine **110** via the outlet **144** after it has been at least partially cooled by the radiator **128**.

Referring to FIG. **4**, the operation of the radiator **128** will be described. When the snowmobile **100** is being operated in the forward direction (indicated by the arrow), the engine **110** drives the track **122** to rotate in the direction **146**. The rotation of the track **122** causes the circulation **148** of cold air and snow within the tunnel **106**, which in turn induces the circulation **149** of cold air along the first side **132** of the radiator **128**, in the direction of rotation **146** of the track **122**. The cold air and snow contact the first side **132** of the radiator **128**, in particular the fins **139**, and absorb heat from the radiator **128**, thereby cooling the coolant circulating therein. The projection **140** induces a turbulent air flow **150** in the area of the rearward opening **152** of the air passage **138**. The air flow **150** creates an area of reduced pressure at the opening **152**. The reduced pressure causes cold air **154** to be drawn through the air passage **138**, along the second side **134** of the radiator **128** in the direction shown. The cold air **154** contacts the second side **134** of the radiator **128**, and absorbs heat from the radiator **128**, further cooling the coolant circulating therein. As can be seen, the circulation of cold air **154** is in the direction opposite that of the circulation **149**.

Both the first side **132** and the second side **134** of the radiator **128** are used for dissipating the heat from the engine **110** to the atmosphere. As a result of the increased surface area of the radiator **128** that is used to dissipate heat to the atmosphere, the radiator **128** can provide adequate cooling for the engine **110**, in some cases without the need for a second radiator, resulting in a lightweight vehicle with a compact cooling system. The absence of a second radiator along the top wall **136** of the tunnel **106** additionally reduces the likelihood of ice build-up on components disposed beneath the rear portion of the tunnel **106**, such as the track **122** and the rear suspension system **124**.

Referring now to FIG. **6**, the operation of an alternative embodiment of a radiator **228** will be described according to a second embodiment. Where the embodiment of FIG. **6** has features similar to those shown in FIG. **4**, they have been given similar reference numbers differing only in the first digit. Some features common to both embodiments are not indicated in FIG. **6** and will not be described again in detail. When the snowmobile **100** is being operated in the forward direction (indicated by the arrow), the track **222** is driven by the engine **110** to rotate in the direction **246**. The rotation of the track **222** causes the circulation of cold air **248** and snow within the tunnel **206**, which induces a circulation **249** of cold air and snow along the first side **232** of the radiator **228**, in the direction of rotation **246** of the track **222**. The cold air and snow contact the first side **232** of the radiator **228**, in particular the fins **239**, and absorb heat from the radiator **228**, thereby cooling the coolant circulating therein. The top wall **236** of the tunnel **206** does not have a feature corresponding to the projection **140** of the embodiment of FIG. **4**. A portion **250** of the cold air **248** is directed toward the opening **252** and drives cold air **254** through the air passage **238**, along the second side **234** of the radiator **228**. The cold air **254** contacts the second side **234** of the radiator **228**, and absorbs heat from the radiator **228**, further cooling the coolant circulating therein. As can be seen, the circulation of cold air **254** is in the same direction as that of the cold air **248**.

Referring now to FIGS. **7**A-**7**C, a number of possible positions are contemplated for the radiator **128**. Referring to FIG. **7**A, the radiator **128**A is installed in the position shown in FIG. **4**, at a forward portion of the tunnel **106**, generally forwardly of the track **122**. The radiator **128**A is spaced apart from the front wall **130**, and an air passage **138**A is formed therebetween. Referring to FIG. **7**B, the radiator **128**B is installed along the top wall **136** of the tunnel **106**, generally above the track **122**. The radiator **128**B is spaced apart from the top wall **136**, and an air passage **138**B is formed therebetween. Referring to FIG. **7**C, the radiator **128**C is installed at a rearward portion of the tunnel **106**, generally rearwardly of the track **122**. The radiator **128**C is spaced apart from the top wall **136** and the rear wall **156** of the tunnel **106**, and an air passage **138**C is formed therebetween. A snow flap **158** may be provided rearwardly of the track **122** to increase the circulation of cold air and snow in the vicinity of the radiator **128**C.

Referring now to FIGS. **8**A-**8**D, a number of alternative shapes are contemplated for the second side **134** of the radiator **128**.

Referring to FIG. **8**A, a lower portion **135**A of the second side **134**A of the radiator **128**A is in contact with the front wall **130** and an upper portion **136**A of the second side **134**A is spaced apart from the front wall **130**. It is contemplated that the lower portion **135**A may comprise 25%, 50% or 75% of the area of the second side **134**A, with the upper portion **136**A comprising the remainder. It should be understood that the transfer of heat to the tunnel **106** will be reduced to a greater extent if the area of the upper portion **136**A is larger relative to the area of the lower portion **135**A.

Referring to FIG. **8**B, the second side **134**B of the radiator **128**B is spaced apart from the front wall **130**. The fins **145**B extend outwardly from the second side **134**B and contact the front wall **130**. The fins **145**B are oriented transversely. In this embodiment, the fins **145**B act as spacers between the second side **134**B and the front wall **130**, and a separate spacer **143** is not needed.

Referring to FIGS. **8**C and **8**D, the second side **134**C of the radiator **128**C has two lateral portions. One lateral portion **135**C is in contact with the front wall **130** and the other lateral portion **136**C is spaced apart from the front wall **130**. It is contemplated that the second side **134**C may have more than two lateral portions, for example left and right lateral portions **135**C in contact with the front wall **130** and a central lateral portion **136**C spaced apart from the front wall **130**. It is contemplated that the lateral portion **135**C may comprise

25%, 50% or 75% of the area of the second side **134**C, with the lateral portion **136**C comprising the remainder. It should be understood that the transfer of heat to the tunnel **106** will be reduced to a greater extent if the area of the upper portion **136**C is larger relative to the area of the lower portion **135**C.

Modifications and improvements to the above-described embodiments of the present invention may become apparent to those skilled in the art. The foregoing description is intended to be exemplary rather than limiting. The scope of the present invention is therefore intended to be limited solely by the scope of the appended claims.

What is claimed is:

1. A snowmobile comprising:

a frame;

a tunnel formed in a rearward portion of the frame;

an engine disposed on the frame;

a drive track disposed at least in part in the tunnel and being operatively connected to the engine for propulsion of the snowmobile;

at least one ski operatively connected to the frame at least in part forwardly of the drive track;

a straddle seat disposed on the frame at least in part above the drive track;

a steering device operatively connected to the at least one ski for steering the snowmobile;

a radiator disposed between the tunnel and the track, the radiator having a first side facing the track and a second side facing the tunnel, the second side being generally opposite the first side,

at least a portion of the second side being spaced apart from the tunnel; and

an air passage between the second side of the radiator and the tunnel,

when the snowmobile is being operated in a forward direction, a direction of air flow along the first side is opposite a direction of air flow in the air passage.

2. The snowmobile of claim **1**, wherein at least 25% of the second side is spaced apart from the tunnel.

3. The snowmobile of claim **1**, wherein at least 50% of the second side is spaced apart from the tunnel.

4. The snowmobile of claim **1**, wherein at least 75% of the second side is spaced apart from the tunnel.

5. The snowmobile of claim **1**, wherein the entire second side is spaced apart from the tunnel.

6. The snowmobile of claim **1**, wherein, when the snowmobile is being operated in the forward direction, the direction of air flow in the air passage is a direction of rotation of the track.

7. The snowmobile of claim **1**, wherein, when the snowmobile is being operated in the forward direction, the direction of air flow in the air passage is a direction opposite the direction of rotation of the track.

8. The snowmobile of claim **1**, wherein the radiator is disposed at least in part forwardly of the track.

9. The snowmobile of claim **8**, wherein:

the tunnel has a front wall; and

the second side of the radiator faces the front wall of the tunnel.

10. The snowmobile of claim **9**, wherein the second side of the radiator generally follows a contour of the front wall of the tunnel.

11. The snowmobile of claim **1**, wherein a top wall of the tunnel has a downwardly-extending projection disposed generally rearwardly of the air passage.

12. The snowmobile of claim **11**, wherein, when the snowmobile is being operated in the forward direction, an area of reduced air pressure is created at a rearward opening of the air passage.

13. The snowmobile of claim **1**, wherein the radiator has an inlet and an outlet, the inlet and the outlet communicating with an interior of the radiator via the second side, the inlet and the outlet passing through the front wall of the tunnel.

14. The snowmobile of claim **1**, wherein the first side of the radiator is generally arcuate.

15. The snowmobile of claim **14**, wherein:

the track is supported by a plurality of axles, one of the plurality of axles being a forwardmost axle; and

the first side of the radiator forms a generally circular arc having a center of curvature approximately at an axis of rotation of the forwardmost axle.

16. The snowmobile of claim **1**, wherein:

the first side of the radiator has a plurality of fins projecting outwardly therefrom in a direction of the track; and

the second side of the radiator has generally flat sections.

17. The snowmobile of claim **1**, wherein:

the first side of the radiator has a first plurality of fins projecting outwardly therefrom in a direction of the track; and

the second side of the radiator has a second plurality of fins projecting outwardly therefrom.

18. The snowmobile of claim **17**, wherein the second plurality of fins contact the tunnel.

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