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Inventor(s)	Kelly; Richard L.

FAN SHROUD AND ROCK SCREEN ASSEMBLY

Abstract

An engine system can comprise an engine and a cooling module assembly which comprises a radiator. In some examples, an assembly, such as the cooling module assembly, can include a radiator and a fan shroud and screen assembly arranged at a rear side of the radiator. The fan shroud and screen assembly includes a screen and first and second shroud portions coupled to and around the screen, where the first and second shroud portions and the screen form a cavity, and where the first and second shroud portions are directly coupled to the rear side of the radiator. The assembly further comprises a fan disposed within the cavity and configured to spin freely within the cavity without being attached to the fan shroud and screen assembly.

Inventors: **Kelly; Richard L. (Forest Grove, OR)**

Applicant: **Daimler Truck North America LLC** (Portland, OR)

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application claims the benefit of U.S. Provisional Patent Application No. 63/552,754, filed Feb. 13, 2024, which is incorporated by reference herein in its entirety.

FIELD
[0002] This disclosure generally relates to radiators, and related components, for engine systems of vehicles.
BACKGROUND
[0003] A vehicle typically includes an engine system with a radiator for cooling an engine. A fan, which may be mounted within a fan shroud, can be disposed between the radiator and the engine. In some instances, during operation of the vehicle, debris can be thrown up toward the fan and/or engine from the tires. This may cause the fan to pick up the debris and send it toward a rear side of the radiator, which can result in degradation of the radiator. A screen (which may comprise metal, for example) can be attached to the rear side of the radiator in order to prevent debris from interacting with the radiator. However, such screens can be expensive, heavy, and reduce airflow through the radiator.
SUMMARY
[0004] Described herein are engine systems, radiators, cooling module assemblies, and fan shroud and rock screen assemblies for an engine system. An engine system for a vehicle can comprise a radiator disposed at a front side of an engine in order to provide cooling to the engine. A fan can be arranged adjacent (e.g., behind) the radiator to pull air through the radiator. During operation of the vehicle, debris can be thrown up toward the rear side of the radiator (the side facing the fan and the engine). Thus, in some examples, the engine system can comprise a fan shroud and rock screen assembly that is configured to mount to the radiator, receive the fan therein, and prevent debris from contacting the radiator. The fan shroud and rock screen assembly can comprise a two-part fan shroud that couples around and to a rock screen. The fan shroud can be directly coupled to the radiator, and the fan shroud and rock screen assembly form a cavity in which the fan can rotate freely (without being directly coupled to any part of the fan shroud and rock screen assembly). The fan shroud and rock screen can be removably coupled to one another via one or more mating interfaces that enable easy servicing of the radiator, fan, or alternate components of the cooling module assembly. In some examples, the fan shroud and rock screen assembly can be formed by injection molding. As such, the fan shroud and rock screen assemblies described herein can be cost effective, lightweight, durable, and allow optimum airflow through the rock screen, thereby maintaining a cooling performance of the radiator.
[0005] In some examples, an assembly can comprise a radiator and a fan shroud and screen assembly arranged at a rear side of the radiator. The fan shroud and screen assembly can comprise a screen and first and second shroud portions coupled to and around the screen. The first and second shroud portions and the screen form a cavity, and the first and second shroud portions are directly coupled to the rear side of the radiator. The assembly can further comprise a fan disposed within the cavity and configured to spin freely within the cavity without being attached to the fan shroud and screen assembly.
[0006] In some examples, an assembly can comprise a rock screen comprising a screen portion and an outer rim, where the screen portion is offset from the outer rim, in an axial direction relative to a central longitudinal axis of the assembly. The assembly can further comprise a first shroud portion removably coupled to a first half of the outer rim and a second shroud portion removably coupled to a second half of the outer rim. When coupled together, the screen portion and the first and second shroud portions form a cavity configured to receive a fan therein.

[0007] In some examples, an engine system can comprise a radiator and a fan shroud and rock screen assembly mounted to a rear side of the radiator. The fan shroud and rock screen assembly can comprise a rock screen and first and second fan shrouds which are each removably coupled to and disposed around the rock screen. The first and second fan shrouds and the rock screen form a cavity on a rear side of the fan shroud and rock screen assembly, and the first and second fan shrouds are directly coupled to the rear side of the radiator. The system can further comprise a fan disposed within the cavity and configured to spin within the cavity, where the fan is configured to pull air through the radiator, from a front side to the rear side of the radiator. The system can further comprise an engine arranged behind the fan shroud and rock screen assembly such that the fan shroud and rock screen assembly is disposed between the radiator and the engine.
[0008] The foregoing and other objects, features, and advantages of the disclosed technology will become more apparent from the following detailed description, which proceeds with reference to the accompanying figures.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0009] FIG. **1** is a perspective view of an exemplary engine system for a vehicle, where the engine system includes an engine and a cooling module assembly.
[0010] FIG. **2** is a rear view of the cooling module assembly of FIG. **1**, where the cooling module assembly includes a radiator and a fan shroud and rock screen assembly for the radiator.
[0011] FIG. **3** is a rear perspective view of the cooling module assembly of FIG. **2**.
[0012] FIG. **4** is a rear view of the fan shroud and rock screen assembly.
[0013] FIG. **5** is a front view of the fan shroud and rock screen assembly of FIG. **4**.
[0014] FIG. **6** is a front perspective view of the fan shroud and rock screen assembly of FIG. **4**.
[0015] FIG. **7** is a rear perspective view of the fan shroud and rock screen assembly of FIG. **4**.
[0016] FIG. **8** is a front exploded view of the fan shroud and rock screen assembly of FIG. **4**.
[0017] FIG. **9**A is a detail view of a portion of the fan shroud and rock screen assembly of FIG. **4**, depicting a removable mating interface between the rock screen and a first shroud portion of the fan shroud.
[0018] FIG. **9**B is another detail view of the portion of the fan shroud and rock screen assembly of FIG. **9**A, which also depicts vanes of the rock screen.
[0019] FIG. **10**A is detail view of a portion of the fan shroud and rock screen assembly of FIG. **4**, depicting a removable mating interface between the rock screen and a second shroud portion of the fan shroud.
[0020] FIG. **10**B is another detail view of the portion of the fan shroud and rock screen assembly of FIG. **4**.
[0021] FIG. **11** is a plan view of an exemplary shape of a rung for the rock screen of the fan shroud and rock screen assembly of FIG. **4**.
[0022] FIG. **12** is an exploded view of an exemplary cooling module assembly including a radiator and fan shroud and rock screen assembly for the radiator.
[0023] FIG. **13** is a rear view of the fan shroud and rock screen assembly of FIG. **12** coupled to the radiator.
[0024] FIG. **14** is a rear, detail view of a portion of the rock screen of the fan shroud and rock screen assembly of FIG. **12**, which depicts vanes of the rock screen.
[0025] FIG. **15** is a front view of the rock screen of the fan shroud and rock screen assembly of FIG. **12**.
[0026] FIG. **16**A is a front, detail view of a portion of the rock screen of FIG. **15**.
[0027] FIG. **16**B is a front, detail view of another portion of the rock screen of FIG. **15**.

[0028] FIG. **17** is a side view of a portion of the rock screen of FIG. **15**.
[0029] FIG. **18** is a side view of a portion of the rock screen of FIG. **8**.
DETAILED DESCRIPTION
Explanation of Terms
[0030] For purposes of this description, certain aspects, advantages, and novel features of the embodiments of this disclosure are described herein. The disclosed methods, apparatus, and systems should not be construed as being limiting in any way. Instead, the present disclosure is directed toward all novel and nonobvious features and aspects of the various disclosed embodiments, alone and in various combinations and sub-combinations with one another. The methods, apparatus, and systems are not limited to any specific aspect or feature or combination thereof, nor do the disclosed embodiments require that any one or more specific advantages be present or problems be solved. The scope of this disclosure includes any features disclosed herein combined with any other features disclosed herein, unless physically impossible.
[0031] Although the operations of some of the disclosed embodiments are described in a particular, sequential order for convenient presentation, it should be understood that this manner of description encompasses rearrangement, unless a particular ordering is required by specific language set forth below. For example, operations described sequentially may in some cases be rearranged or performed concurrently. Moreover, for the sake of simplicity, the attached figures may not show the various ways in which the disclosed methods can be used in conjunction with other methods.
[0032] As used in this disclosure and in the claims, the singular forms “a,” “an,” and “the” include the plural forms unless the context clearly dictates otherwise. Additionally, the term “includes” means “comprises.” Further, the terms “coupled” and “associated” generally mean electrically, electromagnetically, and/or physically (e.g., mechanically or chemically) coupled or linked and does not exclude the presence of intermediate elements between the coupled or associated items absent specific contrary language.
[0033] In the description, certain terms may be used such as “forward,” “front,” “rear,” “back,” “up,” “down,” “upper,” “lower,” “horizontal,” “vertical,” “left,” “right,” “longitudinal,” “lateral,” and the like. These terms are used, where applicable, to provide some clarity of description when dealing with relative relationships. However, these terms are not intended to imply absolute relationships, positions, and/or orientations. For example, with respect to an object, an “upper” surface can become a “lower” surface by turning the object over. Nevertheless, it is still the same object.
[0034] Similar components in different embodiments are described in the specification and illustrated in the figures with similar reference numbers for improved understanding and readability. However, it should be understood that this numbering convention is merely for convenience and is not intended to limit and/or exclude any claim scope.
[0035] Although there are alternatives for various components, parameters, operating conditions, etc., set forth herein, that does not mean that those alternatives are necessarily equivalent and/or perform equally well. Nor does it mean that the alternatives are listed in a preferred order unless stated otherwise.
Overview of the Disclosed Technology
[0036] As introduced above, a motor vehicle (such as a car, truck, semi-trailer truck, etc.) typically includes an engine system including an engine, and a radiator and fan arranged to provide cooling to the engine. In some examples, the fan can be disposed between the radiator and the engine and can be configured to pull air through the radiator (from a front side to a rear or back side of the radiator). In some instances, the fan can be mounted within a fan shroud. During operation of the vehicle, debris can be thrown up toward the fan and/or engine by the vehicle tires. This may cause the fan to pick up the debris and send it toward the rear side of the radiator (the side facing the engine), which can result in degradation of the radiator. A screen (which may comprise metal, for example) can be attached to the rear side of the radiator to prevent debris from interacting with the

radiator. However, such screens can be expensive, heavy, and require more solid structural support regions (due to being directly attached to the radiator and/or fan) that reduce airflow therethrough, thereby reducing airflow through the radiator, and as a result, reducing cooling to the engine.

[0037] Thus, there is a need for assemblies and/or components that are lightweight, durable, cost effective, and have a minimal impact to airflow through the radiator.

[0038] Described herein are examples of an integrated fan shroud and rock screen (or a fan shroud and rock screen assembly) configured to be coupled to a rear side of a radiator of an engine system. A rock screen can be removably coupled to a fan shroud (which can be a 2-part fan shroud in some examples). The fan shroud can be coupled to the rear side of the radiator (and thus the rock screen is not directly coupled to the radiator). In some examples, the integrated fan shroud and rock screen can be formed by injection molding, making the assembly lightweight, durable, and relatively low cost (as compared to a screen made of metal). Further, the rock screen can comprise vanes that are configured to minimize or eliminate the impact to airflow through the radiator when the integrated fan shroud and rock screen are coupled thereto (as compared to the radiator without the integrated fan shroud and rock screen attached thereto). In this way, the integrated fan shroud and rock screen assemblies described herein can maintain an engine cooling performance of the radiator (to be the same or similar to the radiator without an attached rock screen).

Examples of the Disclosed Technology

[0039] FIG. **1** is a perspective view of a portion of an engine system **100**. The engine system **100** can be installed in a motor vehicle, such as a car, truck, semi-trailer truck, etc. As shown in FIG. **1**, the engine system **100** includes an engine **102** (or engine block) and a cooling module assembly **104** configured to cool the engine **102**. It should be noted that the engine system **100** can include additional components than those depicted in FIG. **1**. Further, in some instances, the cooling module assembly shown and described herein can be used within an alternate engine system having a differently configured engine.

[0040] The cooling module assembly **104** is arranged at a front side **106** of the engine **102** (which is disposed opposite a rear side **108** of the engine **102**). In some examples, the front side **106** of the engine **102** can be closer to a front end of the vehicle in which the engine system **100** is installed than the rear side **108** of the engine **102**. Thus, the cooling module assembly **104** can be referred to as being arranged in front of the engine **102**.

[0041] The cooling module assembly **104** is shown apart from the engine **102** in the rear and rear perspective views of FIGS. **2** and **3**, respectively. The cooling module assembly includes a radiator **110** and a fan shroud and rock screen assembly **120** that is mounted to a rear side of the radiator **110**. In some instances, the fan shroud and rock screen assembly **120** can be referred to as a fan shroud and screen assembly **120** (e.g., since the screen of the assembly can block more than just rocks from contacting the radiator).

[0042] As described further below, a fan **140** can spin freely within the fan shroud and rock screen assembly **120**, without being attached to the fan shroud and rock screen assembly **120**. As used herein, “spin freely” can refer to the fan **140** rotating within a cavity defined by the fan shroud and rock screen assembly **120** while no part of the fan **140** is directly coupled to any part of the fan shroud and rock screen assembly **120**.

[0043] The radiator **110** can include a core **112**, a coolant inlet tank **114**, and a coolant outlet tank **116** (see FIG. **1** and FIGS. **12-13**). The radiator **110** can have a front side **117** (that faces away from the engine **102**) and an opposite, rear side **118** (that faces toward the engine **102**).

[0044] The fan shroud and rock screen assembly **120** can also be referred to herein as an integrated fan shroud and rock screen assembly **120** since the rock screen and fan shroud components are coupled together and then coupled as an assembly to the radiator **110**. For example, the fan shroud and rock screen assembly **120** can be coupled to the rear side **118** of the radiator **110**, as shown in FIGS. **1-3**. Thus, the fan shroud and rock screen assembly **120** can be disposed between the radiator **110** and the engine **102** (as shown in FIG. **1**).

[0045] A fan **140** is disposed within and spins freely within the fan shroud and rock screen assembly **120**, as shown in FIG. **1**. The fan **140** is not directly coupled to the fan shroud and rock screen assembly **120**. Instead, in some instances, a central hub of the fan **140** is rotatably coupled to the engine **102**. As shown in FIG. **1** and used herein, the "fan" (e.g., fan **140**) comprises a plurality of fan blades coupled to a central hub that is rotatably coupled to (and rotated by) the engine **102**.
[0046] In some examples, the fan **140** can be referred to as a "puller fan" since it is configured to pull air through the core **112** of the radiator **110**. For example, the fan **140** can pull air from in front of the radiator **110** (e.g., from the front of the vehicle in which the engine system **100** is installed), back through the radiator **110** and toward the engine **102**.
[0047] The fan shroud and rock screen assembly **120** is shown alone in FIGS. **4**-**8**. FIG. **4** is a rear view, FIG. **5** is a front view, FIG. **6** is a front perspective view, FIG. **7** is a rear perspective view, and FIG. **8** is a front exploded view of the fan shroud and rock screen assembly **120**. The fan and rock screen assembly **120** comprises a fan shroud **122** and a rock screen **124** that are removably coupled to one another.
[0048] In some examples, the fan shroud **122** can be a two-part fan shroud that comprises a first shroud portion **126** and a second shroud portion **128**, which couple together to and around the rock screen **124**. In some instances, the first shroud portion **126** can be referred to as the upper shroud portion **126** and the second shroud portion **128** can be referred to as the lower shroud portion, due to their relative arrangements within the engine system **100**, and relative to a ground surface on which the vehicle in which the engine system **100** is installed sits.
[0049] In some examples, the fan shroud and rock screen assembly **120** can be formed by injection molding, and thus comprise an injection-molded plastic. This can result in a relatively lightweight and low-cost component (as compared to more traditional metal rock screen), which is also durable. In some examples, the fan shroud and rock screen assembly **120** can comprise a glass-filled polypropylene.
[0050] The rock screen **124** can have an overall circular shape and comprise an outer rim **130** (or coupling portion) and screen portion **132** (as shown in FIGS. **5**, **6**, and **8**). The screen portion **132** can extend outward from the outer rim **130**, in an axial direction relative to a central longitudinal axis **105** of the fan shroud and rock screen assembly **120** (as shown in FIG. **7**, and which can be co-axial with a rotational axis of the fan **140**). The screen portion **132** can be displaced away from the outer rim **130** (in the axial direction) by a plurality of vanes **172** that extend around a circumference of the rock screen **124**, each vane **172** extending between the outer rim **130** and the screen portion **132** (as shown in FIGS. **6** and **7** and described in greater detail below with reference to FIGS. **9**A-**10**B).
[0051] The screen portion **132** comprises a plurality of rungs **134** that extend circumferentially around or along the screen portion **132**. The rungs **134** can be shaped and arranged to block debris from entering the rock screen **124** (e.g., from its rear end or side, as depicted in FIGS. **3**, **4**, and **7**) with minimal reduction in airflow through the cooling module assembly **104**, as described in further detail below with reference to FIGS. **9**A-**11**.
[0052] The outer rim **130** of the rock screen **124** comprises a plurality of coupling elements (or mating elements) that are configured to couple to corresponding coupling elements on the fan shroud **122**, thereby coupling the rock screen **124** and fan shroud **122** to one another. For example, the rock screen **124** can be coupled to the first shroud portion **126** by a first mating interface and coupled to the second shroud portion **128** by a second mating interface.
[0053] For example, the rock screen **124** comprises a plurality of apertures **136** on a first or upper half **129** of the outer rim **130**. As shown in FIGS. **5** and **8**, the outer rim **130** can comprise four apertures **136** spaced apart from one another around the first or upper half **129** of the outer rim **130**. However, in other examples, the outer rim **130** can comprise more or less than four apertures **136** on its first or upper half **129**, such as two, three, five, or the like.
[0054] The first shroud portion **126** can comprise a plurality of protruding elements **138**

(corresponding to the number of apertures **136**, e.g., four shown in FIG. **8**) that are each configured to extend and snap into a respective aperture **136**. For example, as shown in FIGS. **9**A and **9**B, each protruding element **138** can have two opposing elements or prongs that are biased away from one another such that the protruding element **138** is retained within the respective aperture **136**, and that can be pressed together to release the protruding element **138** from the respective aperture **136**. As a result, the first shroud portion **126** can be releasably coupled to the rock screen **127** via the protruding elements **138** and apertures **136** (which can be referred to as the first mating interface).

[0055] Alternatively, in some examples, instead of protruding elements **138**, the first shroud portion **126** can comprise a plurality of apertures, where each aperture is configured to align with a respective aperture **136** of the outer rim **130** when the first shroud portion **126** and the rock screen **124** are mated together. Each pair of overlapping (or aligned) apertures **136** of the rock screen **124** and apertures of the first shroud portion **126** could be configured to receive a fastener (which may be a bolt, screw, or other known fastener), thereby coupling the outer rim **130** to the first shroud portion **126**).

[0056] The second shroud portion **128** can comprise one or more hooks **142**. As shown in FIGS. **5**, **6**, and **8**, the second shroud portion **128** comprises two hooks **142** that are disposed on opposite sides of the second shroud portion **128**. Each hook **142** is configured to receive therein and hook around a corresponding mating feature on the second or lower half **131** of the outer rim **130** of the rock screen **124**. In some examples, the mating feature on the outer rim **130** is a protrusion **144**, as shown in FIGS. **8**, **10**A, and **10**B. Thus, the complementary hooks **142** and protrusions **144** can be referred to as the second mating interface.

[0057] As shown in FIGS. **5**, **6**, and **8**, the outer rim **130** can comprise two hooks **142** that are spaced apart from one another. However, in other examples, the outer rim **130** can comprise more or less than two hooks **142** on its second or lower half, such as one, three, or the like.

[0058] In some examples, the protrusions **144** can extend outward from the outer rim **130** and have an outward facing surface for receiving the hooks **142** thereon. In some instances, each protrusion **144** can have a raised bump or bead on the outward facing surface that is configured to mate with a corresponding mating feature on the respective hook **142** (such as a concave depression or dimple).

[0059] To couple the rock screen **124** to the second shroud portion **128**, the protrusions **144** of the lower half **131** of the outer rim **130** can slide into the hooks **142** of the second shroud portion **128** (as shown in the detail views of FIGS. **10**A and **10**B). The first shroud portion **126** can then be coupled to the rock screen **124** by inserting the protruding elements **138** into the respective apertures **136** in the outer rim **130** (thereby snapping the rock screen **124** and the first shroud portion **126** together).

[0060] The two-part fan shroud **122** increases the ease of servicing the cooling module assembly **104**. For example, the entire rock screen **124** can be pulled out and away from the remainder of the cooling module assembly **104** (e.g., away from the radiator **110**) along with the first shroud portion **126** because of the hook fasteners (comprising the hooks **142** and protrusions **144**) described above. For example, keeping the first shroud portion **126** coupled to the rock screen **124**, the coupled first shroud portion **126** and rock screen **124** can be pulled up and away from the second shroud portion **128** (thereby uncoupling the protrusions **144** from the hooks **142**). The fan **140**, radiator **110**, and/or other components of the engine system **100** can then be serviced without removing the entire fan shroud and rock screen assembly **120**.

[0061] The assembled fan shroud and rock screen assembly **120** can be coupled to the radiator **110**. More specifically, the first and second shroud portions **126**, **128** can be directly coupled to the radiator **110**, but the rock screen **124** is only coupled to the first and second shroud portions **126**, **128**, as described above (and not directly to the radiator **110**).

[0062] As shown in FIGS. **2**-**8**, the first shroud portion **126** comprises a body **146** and an outer flange **148** extending around at least a portion of a perimeter of the body **146**, and the second shroud portion **128** comprises a body **150** and an outer flange **152** extending around at least a

portion of a perimeter of the body **150**. The bodies **146**, **150** of the respective first and second shroud portions **126**, **128** are offset from the respective outer flanges **148**, **152**, thereby creating a cavity **154** to receive the rock screen **124** therein (as shown in FIGS. **5** and **6**). This arrangement can prevent the outwardly extending screen portion **132** of the rock screen **124** (as described above) from extending past the outer flanges **148**, **152**.

[0063] For example, FIGS. **5** and **6** show the front side **166** of the fan shroud and rock screen assembly **120** which faces the radiator **110** (as shown in FIGS. **2** and **3**). The outer flanges **148**, **152** can comprise first (or front facing) surfaces **156** that mate with (and have face-to-fact contact with) corresponding mating surfaces on the radiator **110** and/or additional components of the engine system **100** (as shown in FIGS. **1**-**3**).

[0064] In some examples, as shown in FIGS. **2**, **4**, and **5**, the flanges **148**, **152** comprise one or more mating features **158** and/or apertures **160** for receiving fasteners therethrough for coupling the fan shroud **122** to the radiator **110**.

[0065] In some examples, a top portion of the flange **148** can comprise recessed portions **162** (recessed from the front side **166** toward the rear side **168** of the fan shroud and rock screen assembly **120**), each containing an aperture **164** for mounting the first shroud portion **126** to a component of the engine system **100**, such as a mounting plate at the top of the radiator **110** and/or directly to the top tank (e.g., coolant inlet tank **114**) of the radiator **110** (e.g., the same or similar to as shown in FIG. **13**).

[0066] In some examples, as shown in FIGS. **3** and **7**, on the rear side **168**, the bodies **146**, **150** of the first and second shroud portions **126**, **128** each comprise a partial annular collar that forms an annular collar **170** around the rock screen **124** when assembled together. Together, the collar **170** and the recessed screen portion **132** (recessed toward the radiator **110** and away from the rear side **168** by the vanes **172**, as described above) form a cavity **174** (shown in FIGS. **3** and **7**) configured to receive the fan **140** therein (as shown in FIG. **1**).

[0067] As introduced above, the screen portion **132** of the rock screen **124** comprises a plurality of rungs **134** that extend circumferentially around the screen portion **132**. The rungs **134** can be shaped and arranged to block debris from entering the rock screen **124** (e.g., from its rear side, as depicted in FIGS. **3**, **4**, and **7**) with minimal reduction in airflow through the cooling module assembly **104**. FIGS. **9**A-**10**B show detail views of portions of the screen portion **132** and the rungs **134**. Each rung **134** can arc between two adjacent radially extending spokes **133** and be spaced radially away from adjacent rungs **134** that are connected to the same two radially extending spokes **133** (a shown in FIGS. **9**A-**10**B).

[0068] FIG. **11** shows an exemplary shape of a rung **134**. In some examples, as shown in FIG. **11**, the rungs **134** can each have an airfoil-type shape with opposing curved sides **135**. In some examples, the rungs **134** can have an oval-like shape. Each rung **134** can have a length **137** and width **139**, where the length to width ratio is in a range of 1.75-2.25, or about 2. The airfoil-type shape of the rungs **134** prevents the rungs **134** of the screen portion **132** from hindering airflow through the rock screen **124** (and thus the radiator **110**).

[0069] As introduced above, the rock screen **124** comprises a plurality of vanes **172** that extend around a circumference of the rock screen **124**, each vane **172** extending between the outer rim **130** and the screen portion **132**. The vanes **172** are configured to direct airflow through the rock screen **124** and the radiator **110**. In particular, the vanes **172** are shaped to pull air from the corners of the fan shroud and rock screen assembly **120** and direct it through the screen portion **132** of the rock screen **124**. For example, the curvature of the vanes **172**, as described further below, can pull air and direct airflow through the screen portion **132** to increase airflow and cooling performance of the radiator relative to a more-traditional metal rock screen. The shape of the vanes **172** of the rock screen **124**, as described herein, can increase an effective open area for airflow of the rock screen **124**. Further, by not needing additional support structure (as in a more traditional metal rock screen), airflow through the rock screen **124** can be further increased.

[0070] As shown in FIGS. **9**A and **9**B, each vane **172** has a base **176** and a tip **178**. The base **176** extends between the outer rim **130** and the screen portion **132**, with a first end **184** disposed at (e.g., connected to) the outer rim **130** and a second end **186** disposed at (e.g., connected to) the screen portion **132**. The tip **178** is spaced away from the base **176** and has a first end **188** disposed at (e.g., connected to) the outer rim **130** and a second end **190** that is spaced away from both the outer rim **130** and the screen portion **132**, and can be referred to as a "free end."
[0071] Each vane **172** has a curved outer surface **180** and a curved inner surface **182**, such that each vane **172** extends radially outward from the screen portion **132** and base **176** and curves in a first direction away from the base **176** (as shown in FIGS. **9**A-**10**B). In this way, all the vanes **172** can curve in a same direction (a first circumferential direction, such as counterclockwise or clockwise direction) around the circumference of the rock screen **124**.
[0072] Openings **192** are formed between adjacent vanes **172**, and between the outer rim **130** and the screen portion **132**. The openings **192** are configured to increase airflow through the rock screen **124**, thereby increasing cooling performance of the radiator **110**.
[0073] FIGS. **12-17** depict a fan shroud and rock screen assembly **220** that is similar to the fan shroud and rock screen assembly **120**, except the rock screen **224** has vanes **272** that have a different profile than the vanes **172** of the rock screen **124**. For example, as explained in more detail below and shown in the side view comparisons of FIGS. **17** and **18**, the vanes **272** (shown in FIG. **17**) are angled relative to the vanes **172** (shown in FIG. **18**), thereby creating larger openings **292** for increased airflow through the rock screen **224** relative to the rock screen **124**.
[0074] In FIGS. **12-17**, the components of the fan shroud and rock screen assembly **220** that are the same as (or similar to) those of the fan shroud and rock screen assembly **120** are labeled correspondingly and are not re-described below for the sake of brevity. For example, the fan shroud and rock screen assembly **220** includes a fan shroud **222** comprising a first shroud portion **226** and a second shroud portion **228**, which can be the same as or similar to the first shroud portion **126** and the second shroud portion **128**, respectively, of the fan shroud **122**. Thus, the first shroud portion **226** and second shroud portion **228** can couple to the rock screen **224** and the radiator **110** the same or similar to as described above for the fan shroud and rock screen assembly **120**.
[0075] Further, the fan shroud and rock screen assembly **220** includes the rock screen **224** comprising an outer rim **230** and screen portion **232** which can be the same or similar to the outer rim **130** and the screen portion **132** of the rock screen **124**. As shown in FIG. **15**, the outer rim **230** can have trimmed or non-circular edges at its top and bottom portions. In some examples, the outer rim **130** of the rock screen **132** can have this same shape in order to fit with a shape of the first shroud portion **126** and second shroud portion **128**.
[0076] Turning to FIGS. **12-17**, the fan shroud and rock screen assembly **220** is shown as part of a cooling module assembly **204** that includes the radiator **110** in FIG. **12** (exploded view) and FIG. **13** (assembled view). In some examples, the cooling module assembly **204** can replace the cooling module assembly **104** in the engine system **100**.
[0077] As shown in FIGS. **12** and **13**, the first shroud portion **226** comprises a body **246** and an outer flange **248** extending around at least a portion of a perimeter of the body **246**, and the second shroud portion **228** comprises a body **250** and an outer flange **252** extending around at least a portion of a perimeter of the body **250**.
[0078] In some examples, as shown in FIGS. **12** and **13**, the bodies **246**, **250** of the first and second shroud portions **226**, **228** each comprise a partial annular collar that forms an annular collar **270** around the rock screen **224** when assembled together. Together, the collar **270** and the recessed screen portion **232** of the rock screen **224** (recessed toward the radiator **110** by the vanes **272**, as described above for the screen portion **132** and vanes **172**) form a cavity **274** configured to receive the fan **140** therein (e.g., as shown in FIG. **1**).
[0079] FIG. **14** is a rear, detail view of a portion of the rock screen **224** showing a portion of the vanes **272** and rungs **234**. FIG. **15** is a front view of the full rock screen **224**, while FIGS. **16**A and

16B are front, detail views of portions of the rock screen **224** coupled to the fan shroud **222**.
[0080] The rock screen **224** comprises a plurality of vanes **272** that extend around a circumference of the rock screen **224**, each vane **272** extending between the outer rim **230** and the screen portion **232**. The vanes **272** are configured to direct airflow through the rock screen **224** and the radiator **110**. In particular, the vanes **272** are shaped to pull air from the corners of the fan shroud and rock screen assembly **220** and direct it through the screen portion **232** of the rock screen **224**. For example, the curvature of the vanes **272**, as described further below, can pull air and direct airflow through the screen portion **232** to increase airflow through the rock screen **224** (and thus cooling performance of the radiator), as compared to more traditional metal rock screens that require additional support structures and have differently-shape vanes.
[0081] As shown in FIGS. **16**A and **16**B, each vane **272** has a base **276** and a tip **278**. The base **276** extends between the outer rim **230** and the screen portion **232**, with a first end **284** disposed at (e.g., connected to) the outer rim **230** and a second end **286** disposed at (e.g., connected to) the screen portion. The tip **278** is spaced away from the base **276** and has a first end **288** disposed at (e.g., connected to) the outer rim **230** and a second end **290** that is spaced away from both the outer rim **230** and the screen portion **232**, and can be referred to as a "free end".
[0082] Each vane **272** has a curved outer surface **280** and a curved inner surface **282**, such that each vane **272** extends radially outward from the screen portion **232** and base **276** and curves in a first direction away from the base **276** (as shown in FIGS. **15-16**B). In this way, all the vanes **272** can curve in a same direction (a first circumferential direction, such as counterclockwise or clockwise direction) around the circumference of the rock screen **224**.
[0083] Openings **292** are formed between adjacent vanes **272**, and between the outer rim **230** and the screen portion **232**. The openings **292** are configured to increase airflow through the rock screen **224**, thereby increasing cooling performance of the radiator **110**.
[0084] FIGS. **17** and **18** are partial side views of the rock screens **224** and **124**, respectively, showing a difference in the shape of the vanes **272** and **172**. As shown in FIG. **18**, the vanes **172** of the rock screen **124** extend between the outer rim **130** and screen portion **132** in a direction that is parallel or relatively parallel to a central longitudinal axis **105** of the fan shroud and rock screen assembly **120**. Said another way, the vanes **172** extend straight between the outer rim **130** and the screen portion **132** without angling.
[0085] In contrast, as shown in FIG. **19**, the vanes **272** of the rock screen **224** extend between the outer rim **230** and the screen portion **232** at an angle **294**. Said another way, the vanes **272** are angled between the outer rim **230** and the screen portion **232**. The angle **294** is a non-zero angle, and in some examples is in a range of 15-50 degrees, 18-45 degrees, or 20-40 degrees. In some examples, the angle **294** of vanes **272** in an outer row of vanes can be about 20 degrees (e.g., 18-22 degrees). In some examples, vanes **272** in more inner rows of vanes can be larger than 20 degrees. The angling of the vanes **272**, as compared to the straight vanes **172**, creates even larger openings **292** for increased airflow through the rock screen **224** and improved cooling performance of the radiator **110**.
[0086] In this way, an integrated fan shroud and rock screen assembly can prevent debris from contacting and/or degrading a radiator to which the fan shroud and rock screen assembly is coupled, while also being durable and relatively low cost and easy to service (as compared to metal rock screens or rock screens that are directly coupled to the radiator). In some examples, the fan shroud and rock screen assembly can be injection molded, thereby making it cost effective and easy to manufacture. As noted above, the rock screen of the fan shroud and rock screen assembly is not directly coupled to the radiator or the fan. As a result, the rock screen is decoupled from the direct load path of the radiator and fan, and thus the durability of the rock screen is increased without requiring added structural support regions (and thus airflow through the fan shroud and rock screen assembly can be increased). Further, by having a two-part fan shroud that is removably coupled to the rock screen, the rock screen can be removed with only one part of the two-part fan shroud,

thereby making the cooling module assembly of the engine system easier to service. For example, the hook features on the second shroud portion of the rock screen make the rock screen and first shroud portion particularly easy to remove from the cooling module assembly without removing the entire fan shroud and rock screen assembly.

Additional Examples of the Disclosed Technology

[0087] In view of the above-described implementations of the disclosed subject matter, this application discloses the additional examples enumerated below. It should be noted that one feature of an example in isolation or more than one feature of the example taken in combination and, optionally, in combination with one or more features of one or more further examples are further examples also falling within the disclosure of this application.

[0088] The features described herein with regard to any example can be combined with other features described in any one or more of the other examples, unless otherwise stated. For example, any one or more features of one vehicle can be combined with any one or more features of another vehicle. As another example, any one or more features of one splash shield assembly can be combined with any one or more features of another splash shield assembly.

[0089] Example 1. An assembly comprising: a radiator; a fan shroud and screen assembly arranged at a rear side of the radiator, wherein the fan shroud and screen assembly comprises: a screen; and first and second shroud portions coupled to and around the screen, wherein the first and second shroud portions and the screen form a cavity, and wherein the first and second shroud portions are directly coupled to the rear side of the radiator; and a fan disposed within the cavity and configured to spin freely within the cavity without being attached to the fan shroud and screen assembly.

[0090] Example 2. The assembly of any example herein, particularly example 1, wherein the first shroud portion is removably coupled to the screen by a first mating interface, and wherein the second shroud portion is removably coupled to the screen by a second mating interface.

[0091] Example 3. The assembly of any example herein, particularly example 2, wherein the first mating interface comprises a plurality of apertures spaced apart on an outer rim of the screen and a plurality of protruding elements spaced apart on the first shroud portion, wherein each protruding element of the plurality of protruding elements is configured to extend into and couple to a respective aperture of the plurality of apertures.

[0092] Example 4. The assembly of any example herein, particularly either example 2 or example 3, wherein the second mating interface comprises hooks spaced apart from one another on the second shroud portion and complementary protrusions spaced apart from one another on an outer rim of the screen, wherein each hook is configured to receive a respective one of the complementary protrusions.

[0093] Example 5. The assembly of any example herein, particularly any one of examples 1-4, wherein the screen comprises an outer rim, a screen portion, and a plurality of vanes that are spaced apart from one another around a circumference of the screen, wherein the plurality of vanes offset the screen portion from the outer rim in an axial direction that is relative to a central longitudinal axis of the fan shroud and screen assembly.

[0094] Example 6. The assembly of any example herein, particularly example 5, wherein each vane curves radially outward from the screen portion and in a first circumferential direction, and wherein openings for airflow are defined between adjacent vanes of the plurality of vanes and between the outer rim and the screen portion.

[0095] Example 7. The assembly of any example herein, particularly either example 5 or example 6, wherein the screen portion comprises a plurality of circumferentially extending rungs, and wherein each rung has an airfoil shape with opposing curved sides.

[0096] Example 8. The assembly of any example herein, particularly any one of examples 1-7, wherein the screen comprises an outer rim that is removably coupled to the first and second shroud portions and a screen portion that is recessed relative to the outer rim, toward the radiator.

[0097] Example 9. The assembly of any example herein, particularly any one of examples 1-8,

wherein the first and second shroud portions each comprise a body and outer flange, and wherein the outer flange of each of the first and second shroud portions is directly coupled to the rear side of the radiator.

[0098] Example 10. The assembly of any example herein, particularly any one of examples 1-9, further comprising an engine block, and wherein the fan shroud and rock screen assembly is disposed between the radiator and the engine block.

[0099] Example 11. An assembly comprising: a rock screen comprising a screen portion and an outer rim, wherein the screen portion is offset from the outer rim, in an axial direction relative to a central longitudinal axis of the assembly; a first shroud portion removably coupled to a first half of the outer rim; and a second shroud portion removably coupled to a second half of the outer rim, wherein when coupled together, the screen portion and the first and second shroud portions form a cavity configured to receive a fan therein.

[0100] Example 12. The assembly of any example herein, particularly example 11, wherein the screen portion is offset from the outer rim by a plurality of vanes that are spaced apart around a circumference of the rock screen, each vane extending between the outer rim and the screen portion.

[0101] Example 13. The assembly of any example herein, particularly example 12, wherein each vane comprises a base and a tip, wherein the base extends between the screen portion and the outer rim, and wherein the tip is spaced radially and circumferentially away from the base and extends outward from the outer rim to a free end of the tip that is unattached to the screen portion.

[0102] Example 14. The assembly of any example herein, particularly any one of examples 11-13, wherein the screen portion comprises a plurality of rungs that extend circumferentially around the screen portion, and wherein the rungs are shaped and arranged to block debris from entering the rock screen without hindering airflow through the rock screen.

[0103] Example 15. The assembly of any example herein, particularly any one of examples 11-14, wherein the first half of the outer rim is an upper half and comprises a plurality of apertures, and wherein the first shroud portion comprises a plurality of protruding elements, each protruding element configured to be removably coupled with a respective aperture of the plurality of apertures.

[0104] Example 16. The assembly of any example herein, particularly any one of examples 11-15, wherein the second half of the outer rim is a lower half and comprises one or more protrusions, and wherein the second shroud portion comprises one or more hooks, each hook configured to receive a respective protrusion of the one or more protrusions.

[0105] Example 17. The assembly of any example herein, particularly any one of examples 11-16, wherein the first shroud portion comprises a first body and a first outer flange extending around at least a portion of a perimeter of the first body, wherein the second shroud portion comprises a second body and a second outer flange extending around at least a portion of a perimeter of the second body, wherein the first and second bodies are offset from the first and second outer flanges, respectively, thereby forming a cavity, and wherein the screen portion is disposed in the cavity and the outer rim is removably coupled to the first and second bodies.

[0106] Example 18. An engine system comprising: a radiator; a fan shroud and rock screen assembly mounted to a rear side of the radiator, wherein the fan shroud and rock screen assembly comprises: a rock screen; and first and second fan shrouds which are each removably coupled to and disposed around the rock screen, wherein the first and second fan shrouds and the rock screen form a cavity on a rear side of the fan shroud and rock screen assembly, and wherein the first and second fan shrouds are directly coupled to the rear side of the radiator; a fan disposed within the cavity and configured to spin within the cavity, wherein the fan is configured to pull air through the radiator, from a front side to the rear side of the radiator; and an engine arranged behind the fan shroud and rock screen assembly such that the fan shroud and rock screen assembly is disposed between the radiator and the engine.

[0107] Example 19. The engine system of any example herein, particularly example 18, wherein

the rock screen comprises a screen portion and an outer rim, wherein the screen portion is offset from the outer rim, in an axial direction relative to a central longitudinal axis of the fan shroud and rock screen assembly, toward the radiator.
[0108] Example 20. The engine system of any example herein, particularly either example 18 or example 19, wherein the rock screen comprises a plurality of circumferentially extending rungs and a plurality of vanes spaced apart around a perimeter of the rock screen and curving in a same direction around the rock screen.
[0109] In view of the many possible ways in which the principles of the disclosure may be applied, it should be recognized that the illustrated configurations depict examples of the disclosed technology and should not be taken as limiting the scope of the disclosure nor the claims. Rather, the scope of the claimed subject matter is defined by the following claims and their equivalents.

Claims

1. An assembly comprising: a radiator; a fan shroud and screen assembly arranged at a rear side of the radiator, wherein the fan shroud and screen assembly comprises: a screen; and first and second shroud portions coupled to and around the screen, wherein the first and second shroud portions and the screen form a cavity, and wherein the first and second shroud portions are directly coupled to the rear side of the radiator; and a fan disposed within the cavity and configured to spin freely within the cavity without being attached to the fan shroud and screen assembly.
2. The assembly of claim 1, wherein the first shroud portion is removably coupled to the screen by a first mating interface, and wherein the second shroud portion is removably coupled to the screen by a second mating interface.
3. The assembly of claim 2, wherein the first mating interface comprises a plurality of apertures spaced apart on an outer rim of the screen and a plurality of protruding elements spaced apart on the first shroud portion, wherein each protruding element of the plurality of protruding elements is configured to extend into and couple to a respective aperture of the plurality of apertures.
4. The assembly of claim 2, wherein the second mating interface comprises hooks spaced apart from one another on the second shroud portion and complementary protrusions spaced apart from one another on an outer rim of the screen, wherein each hook is configured to receive a respective one of the complementary protrusions.
5. The assembly of claim 1, wherein the screen comprises an outer rim, a screen portion, and a plurality of vanes that are spaced apart from one another around a circumference of the screen, wherein the plurality of vanes offset the screen portion from the outer rim in an axial direction that is relative to a central longitudinal axis of the fan shroud and screen assembly.
6. The assembly of claim 5, wherein each vane curves radially outward from the screen portion and in a first circumferential direction, and wherein openings for airflow are defined between adjacent vanes of the plurality of vanes and between the outer rim and the screen portion.
7. The assembly of claim 5, wherein the screen portion comprises a plurality of circumferentially extending rungs, and wherein each rung has an airfoil shape with opposing curved sides.
8. The assembly of claim 1, wherein the screen comprises an outer rim that is removably coupled to the first and second shroud portions and a screen portion that is recessed relative to the outer rim, toward the radiator.
9. The assembly of claim 1, wherein the first and second shroud portions each comprise a body and outer flange, and wherein the outer flange of each of the first and second shroud portions is directly coupled to the rear side of the radiator.
10. The assembly of claim 1, further comprising an engine block, and wherein the fan shroud and rock screen assembly is disposed between the radiator and the engine block.
11. An assembly comprising: a rock screen comprising a screen portion and an outer rim, wherein the screen portion is offset from the outer rim, in an axial direction relative to a central longitudinal

axis of the assembly; a first shroud portion removably coupled to a first half of the outer rim; and a second shroud portion removably coupled to a second half of the outer rim, wherein when coupled together, the screen portion and the first and second shroud portions form a cavity configured to receive a fan therein.

12. The assembly of claim 11, wherein the screen portion is offset from the outer rim by a plurality of vanes that are spaced apart around a circumference of the rock screen, each vane extending between the outer rim and the screen portion.

13. The assembly of claim 12, wherein each vane comprises a base and a tip, wherein the base extends between the screen portion and the outer rim, and wherein the tip is spaced radially and circumferentially away from the base and extends outward from the outer rim to a free end of the tip that is unattached to the screen portion.

14. The assembly of claim 11, wherein the screen portion comprises a plurality of rungs that extend circumferentially around the screen portion, and wherein the rungs are shaped and arranged to block debris from entering the rock screen without hindering airflow through the rock screen.

15. The assembly of claim 11, wherein the first half of the outer rim is an upper half and comprises a plurality of apertures, and wherein the first shroud portion comprises a plurality of protruding elements, each protruding element configured to be removably coupled with a respective aperture of the plurality of apertures.

16. The assembly of claim 11, wherein the second half of the outer rim is a lower half and comprises one or more protrusions, and wherein the second shroud portion comprises one or more hooks, each hook configured to receive a respective protrusion of the one or more protrusions.

17. The assembly of claim 11, wherein the first shroud portion comprises a first body and a first outer flange extending around at least a portion of a perimeter of the first body, wherein the second shroud portion comprises a second body and a second outer flange extending around at least a portion of a perimeter of the second body, wherein the first and second bodies are offset from the first and second outer flanges, respectively, thereby forming a cavity, and wherein the screen portion is disposed in the cavity and the outer rim is removably coupled to the first and second bodies.

18. An engine system comprising: a radiator; a fan shroud and rock screen assembly mounted to a rear side of the radiator, wherein the fan shroud and rock screen assembly comprises: a rock screen; and first and second fan shrouds which are each removably coupled to and disposed around the rock screen, wherein the first and second fan shrouds and the rock screen form a cavity on a rear side of the fan shroud and rock screen assembly, and wherein the first and second fan shrouds are directly coupled to the rear side of the radiator; a fan disposed within the cavity and configured to spin within the cavity, wherein the fan is configured to pull air through the radiator, from a front side to the rear side of the radiator; and an engine arranged behind the fan shroud and rock screen assembly such that the fan shroud and rock screen assembly is disposed between the radiator and the engine.

19. The engine system of claim 18, wherein the rock screen comprises a screen portion and an outer rim, wherein the screen portion is offset from the outer rim, in an axial direction relative to a central longitudinal axis of the fan shroud and rock screen assembly, toward the radiator.

20. The engine system of claim 18, wherein the rock screen comprises a plurality of circumferentially extending rungs and a plurality of vanes spaced apart around a perimeter of the rock screen and curving in a same direction around the rock screen.