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Davis

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(54) **CONTINUOUSLY VARIABLE TRANSMISSION COOLING**

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F16H 9/18 (2006.01)
F16H 57/027 (2012.01)
F16H 57/035 (2012.01)

(52) **U.S. Cl.**

CPC ***F16H 57/0416*** (2013.01); ***F16H 9/18*** (2013.01); ***F16H 57/027*** (2013.01); ***F16H 57/035*** (2013.01); ***F16H 57/0489*** (2013.01)

(58) **Field of Classification Search**

CPC F16H 57/0489; F16H 57/0416; F16H 57/035; F16H 57/0415; F16H 57/027; B60K 11/06

USPC 474/8, 93, 144

See application file for complete search history.

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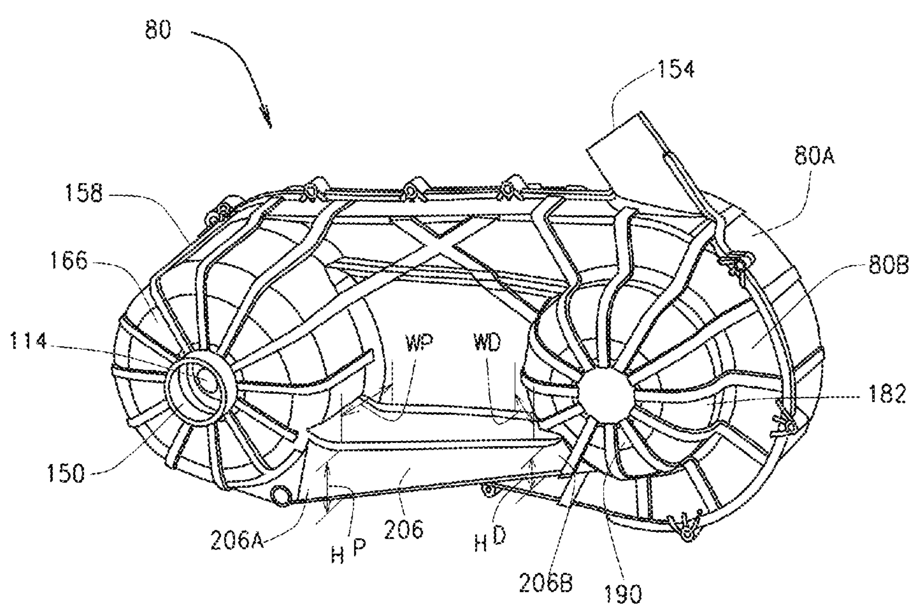
(57) **ABSTRACT**

An off-road utility vehicle comprising a prime mover and a continuously variable transmission, wherein the transmission comprises a housing including an inner cover and an outer cover connectable to the inner cover to provide the housing having an interior chamber defined therein. The housing outer cover comprises a primary clutch dome defining a primary clutch chamber within the interior chamber of the housing, a secondary clutch dome defining a secondary clutch chamber within the interior chamber of the housing, and an air passage extending from the primary clutch dome at a proximal end to the secondary clutch dome at a distal end, the air passage structured and operable to direct air from the primary clutch chamber to the secondary clutch chamber.

24 Claims, 10 Drawing Sheets



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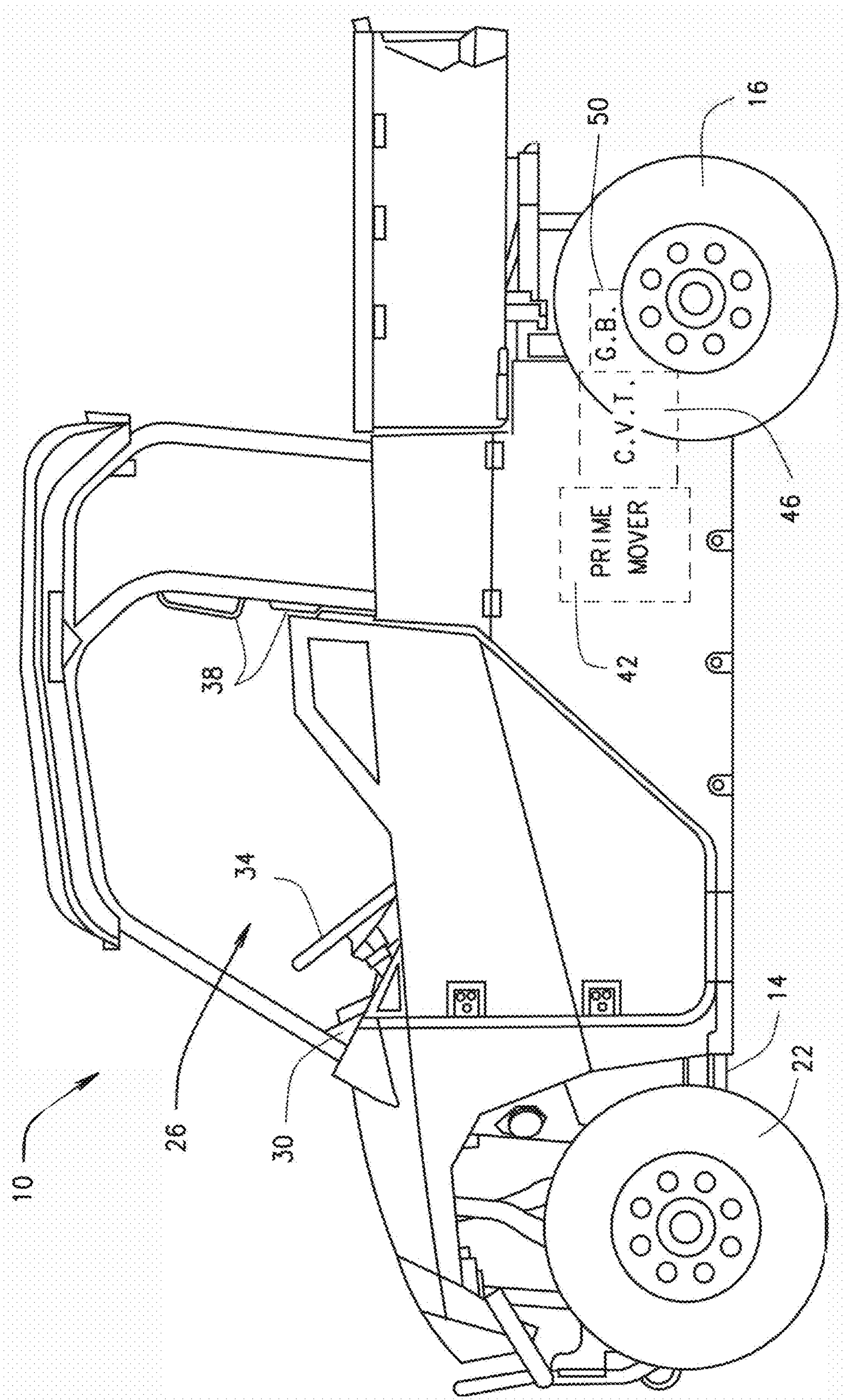


FIG. 1

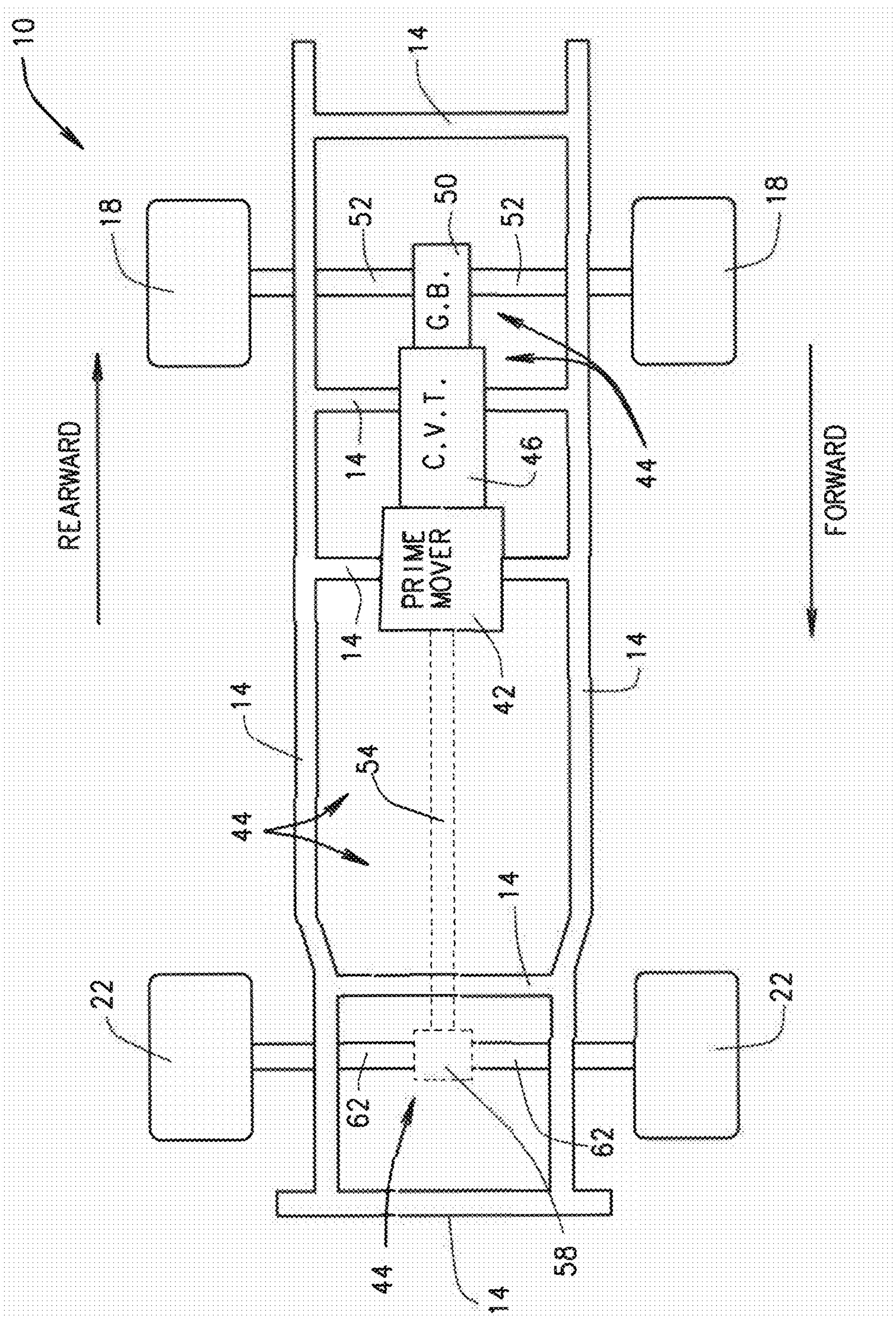
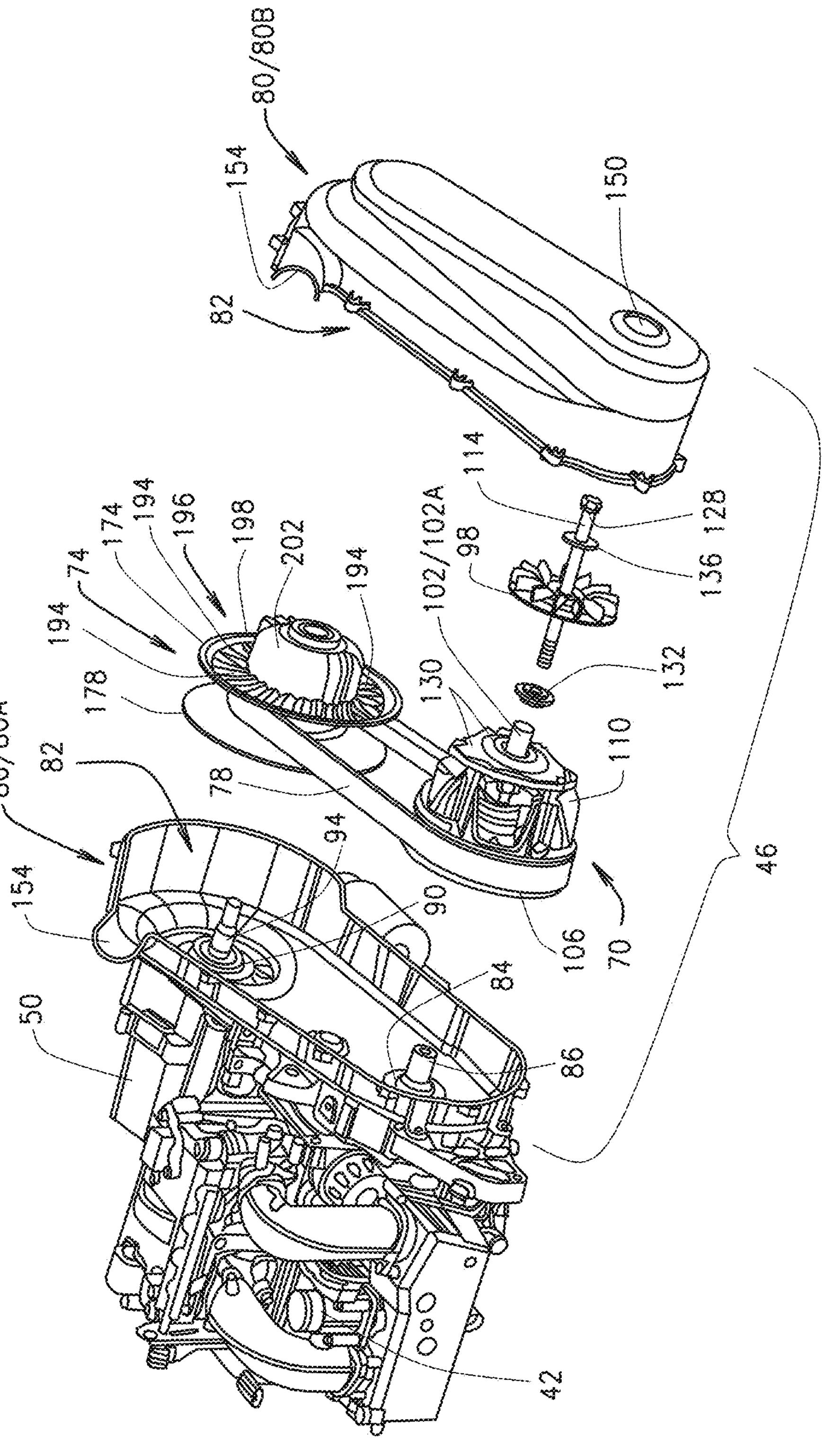

10
14
18
52
50
52
18
G.B.
C.V.T.
14
46
44
REARWARD
FORWARD
PRIME MOVER
14
42
14
14
54
44
14
14
22
22
62
62
44
14
58

FIG. 2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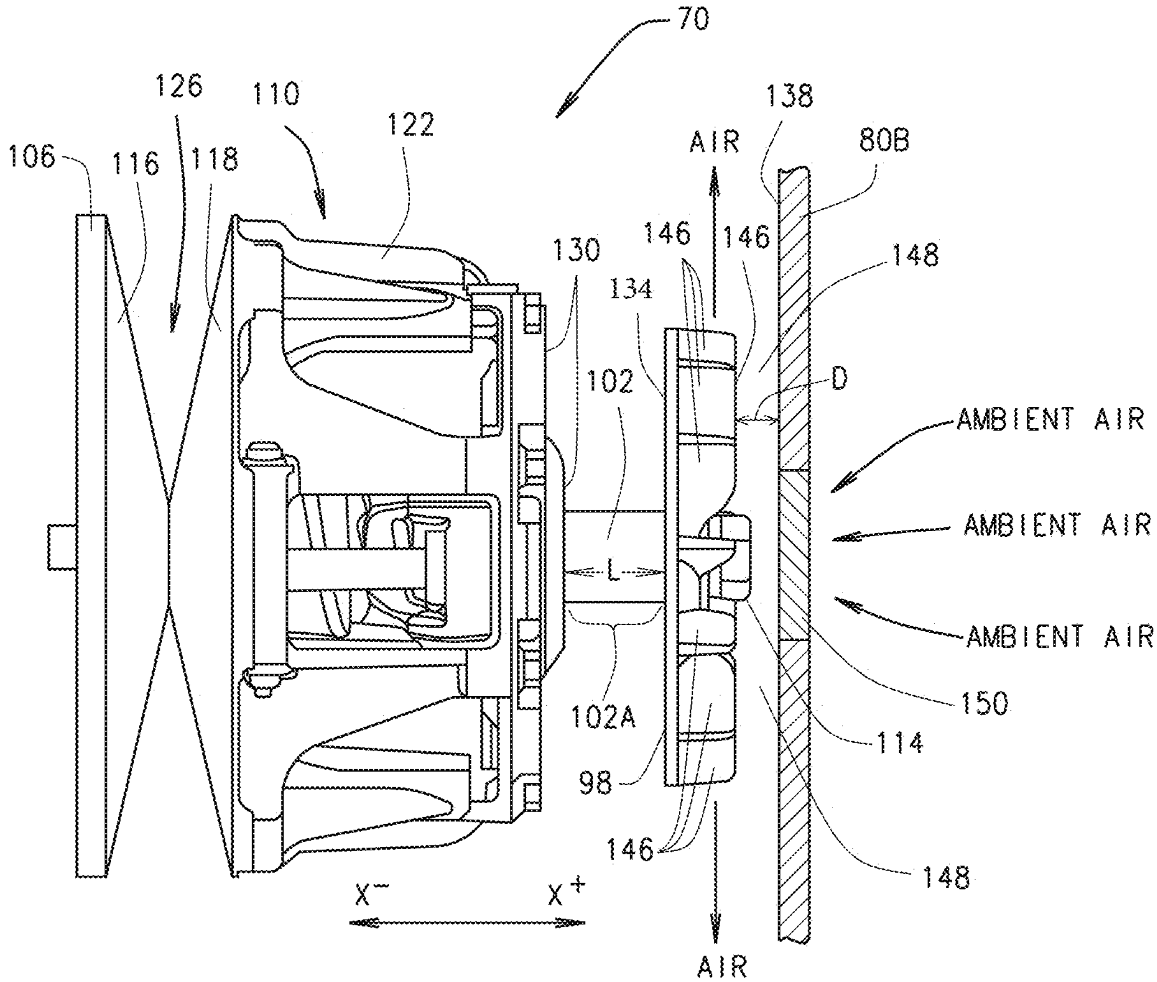
86
42

FIG. 3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148
X⁻
X⁺
AIR

FIG. 4

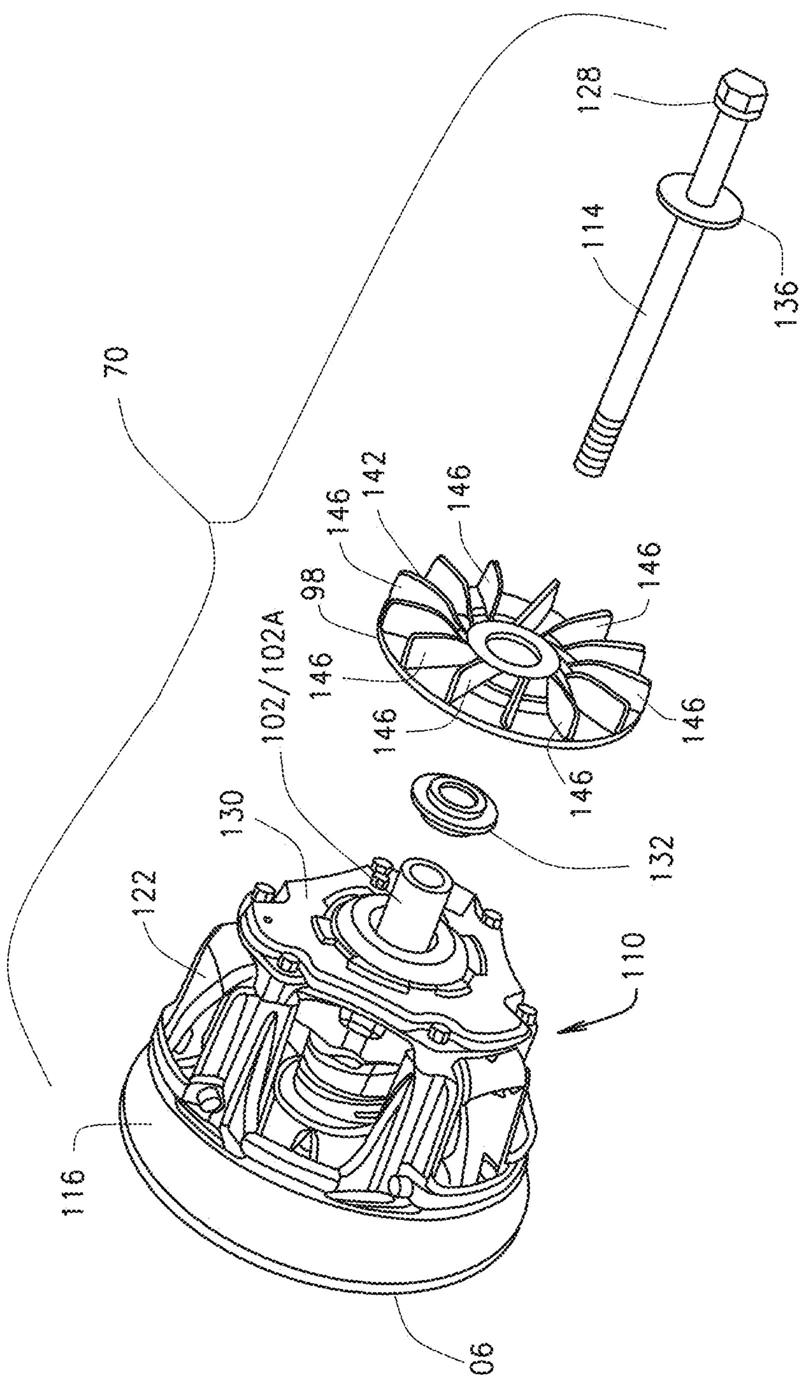

FIG. 5

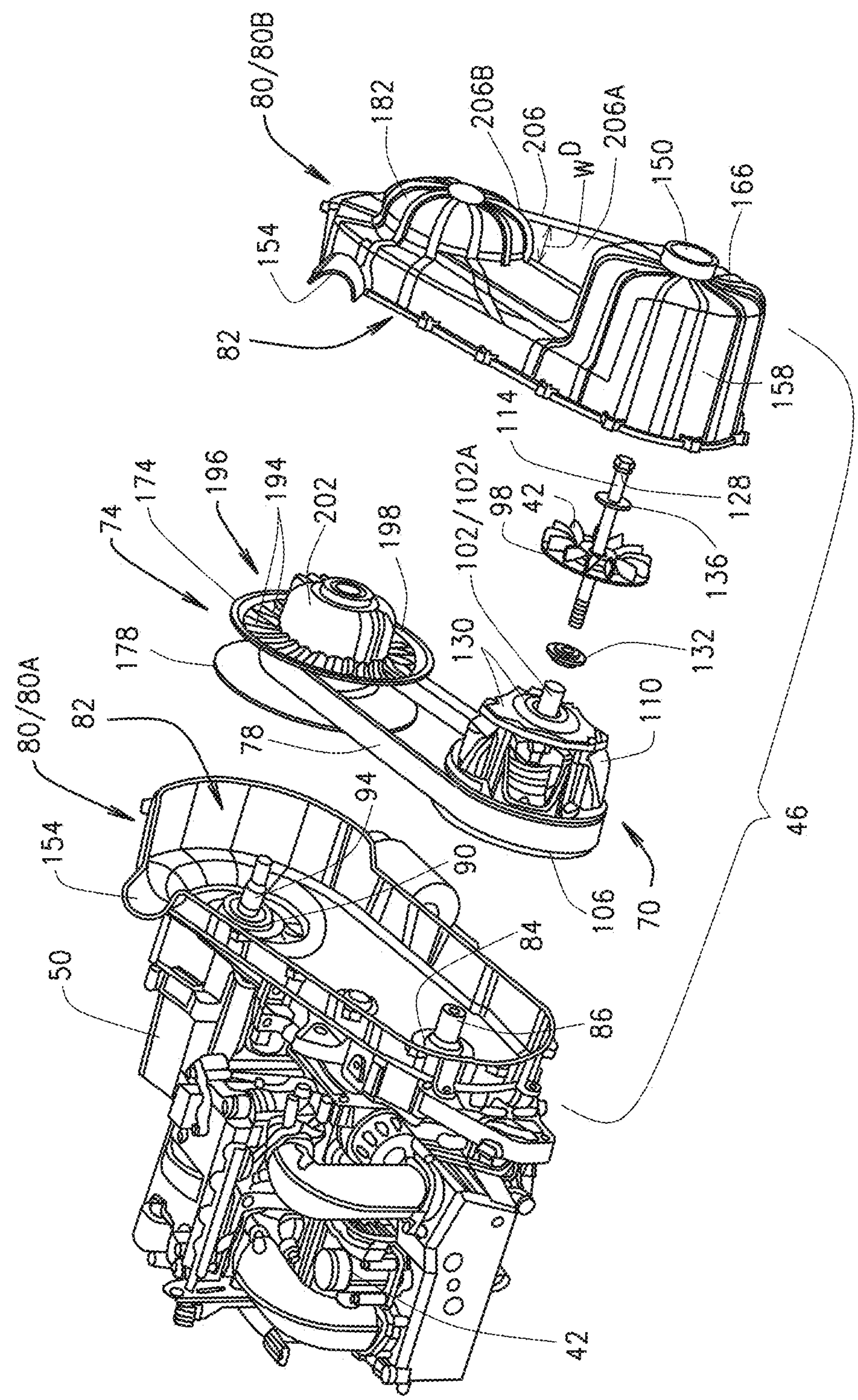
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FIG. 6

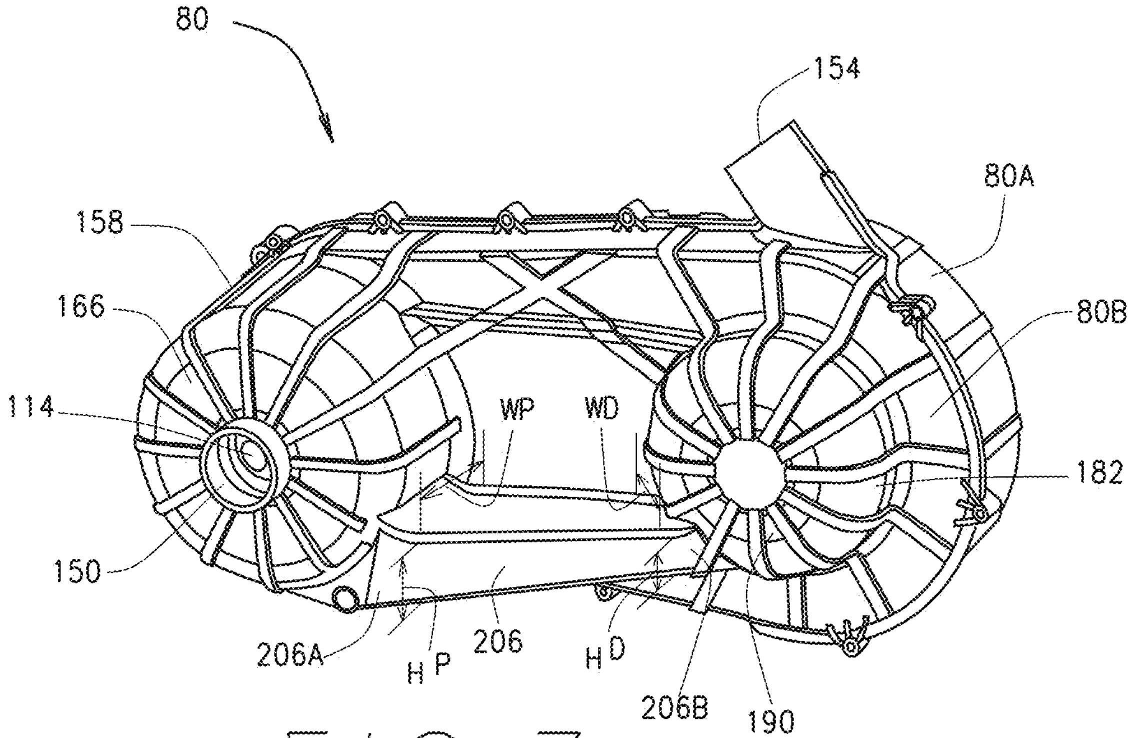
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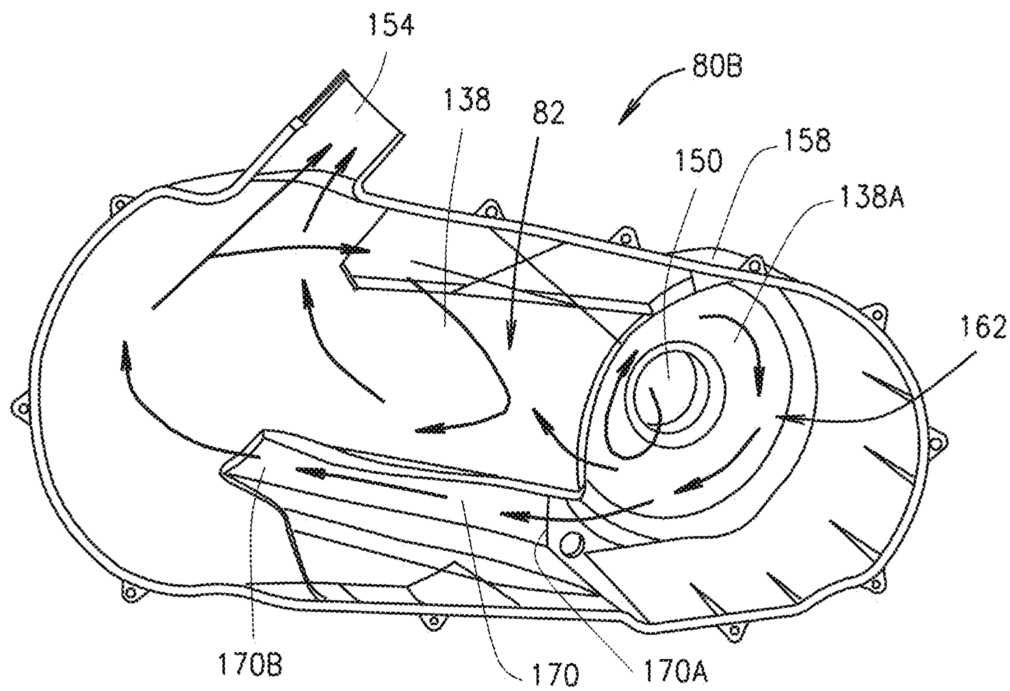
FIG. 7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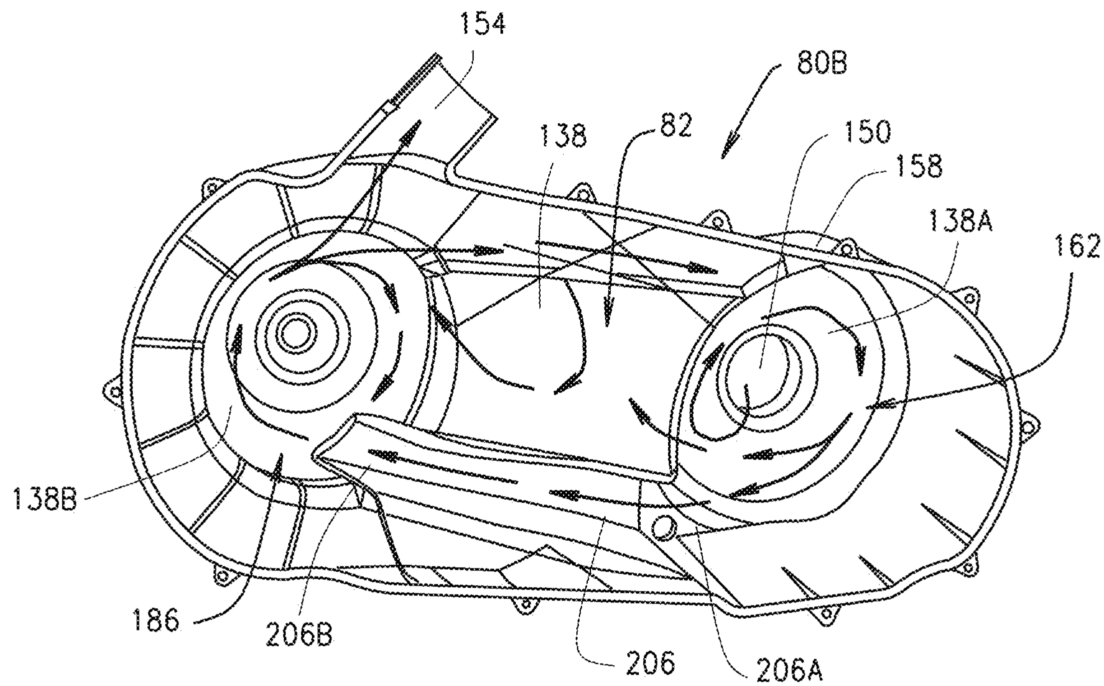
170A

FIG. 8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206A

FIG. 9

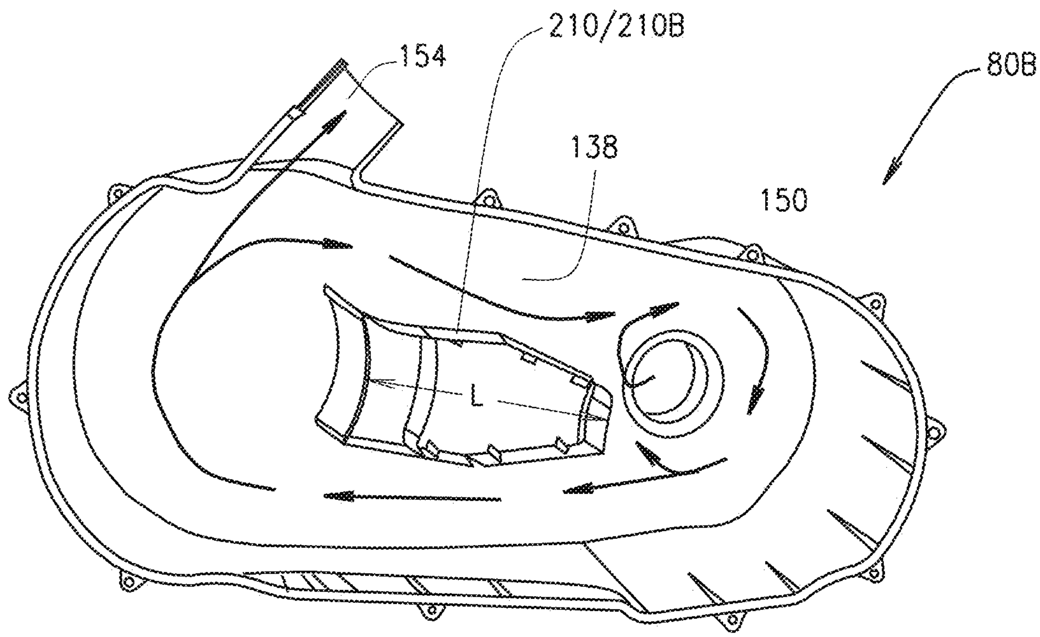
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FIG. 11

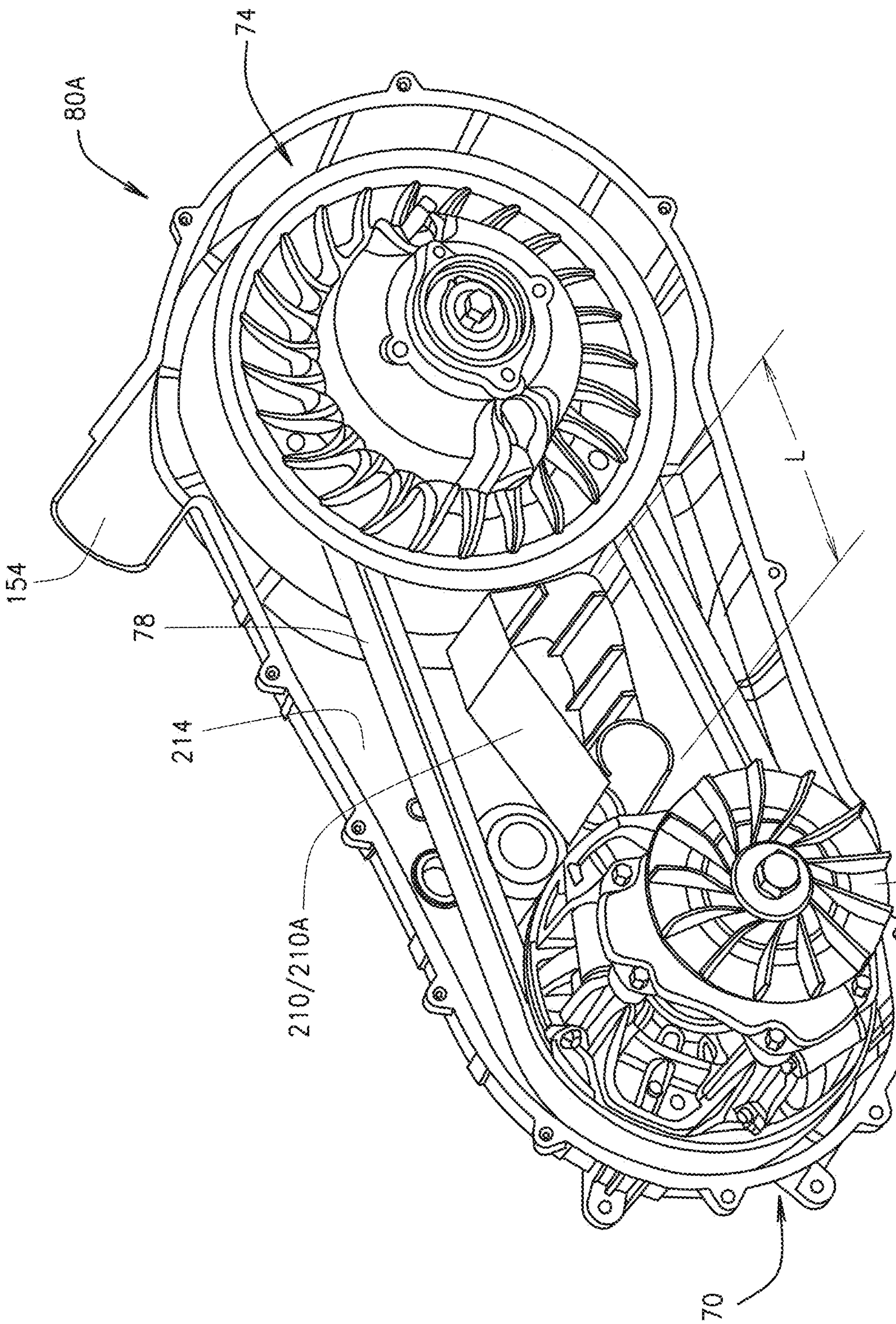

FIG. 10

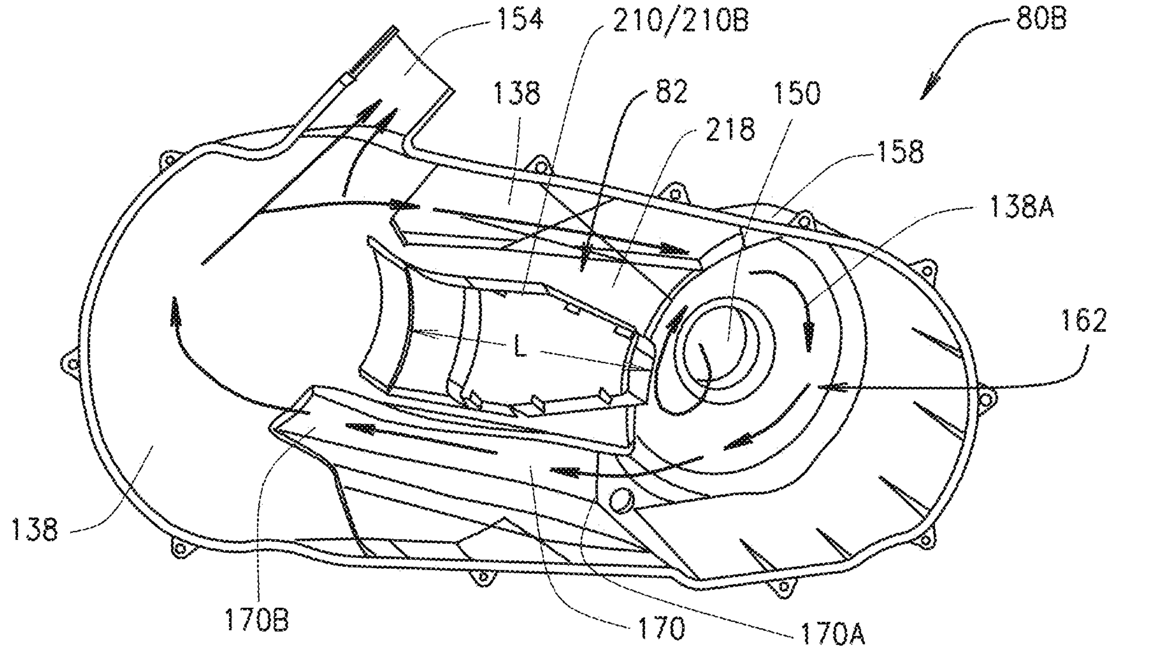
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FIG. 12

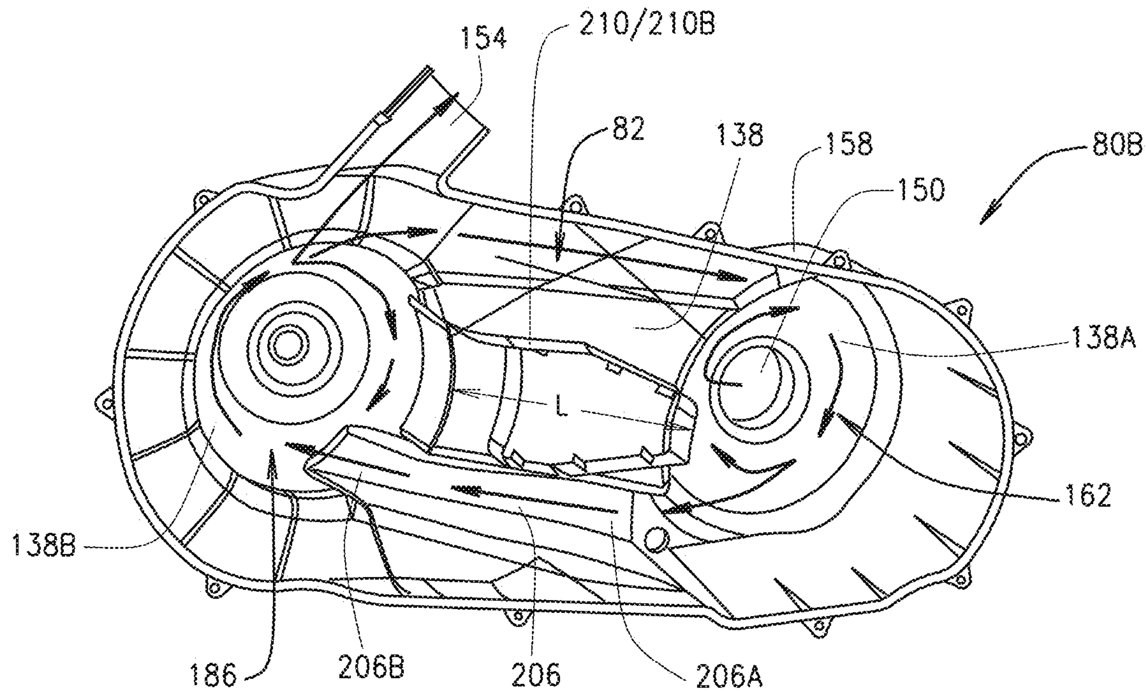
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FIG. 13

CONTINUOUSLY VARIABLE TRANSMISSION COOLING

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 17/944,373 filed on Sep. 14, 2022, which is a continuation of U.S. patent application Ser. No. 16/563,163 filed on Sep. 6, 2019, which is a continuation of U.S. patent application Ser. No. 15/444,470 filed on Feb. 28, 2017, the disclosures of which are incorporated herein by reference in their entirety.

FIELD

The present teachings relate to continuously variable transmissions (CVTs), and more particularly to systems and method for cooling CVTs.

BACKGROUND

The statements in this section merely provide background information related to the present disclosure and may not constitute prior art.

Many of today's lightweight vehicles that are not designated for use on roadways, e.g., all-terrain vehicles (ATVs), utility terrain vehicles (UTVs), etc., implement a continuously variable transmission (CVT) to transfer and control the distribution of torque within the vehicle drivetrain. Due to the dust, water, mud, rocks, etc., commonly encountered in off-road environments, such CVTs typically comprise a housing or cover designed to protect the components, e.g., primary clutch, secondary clutch, bushings, belts, etc., from the environment. However, such covers substantially enclose the components and trap heat generated during operation of the CVT such that the components do not easily cool off causing degradation in the life of the components. Additionally, in higher horsepower vehicles, greater heat is generated, which will degrade the internal parts of the CVT faster. Known system designs for cooling the internal components of CVTs have a fan located on the inside, or stationary, sheave of the primary clutch and/or the outside, or stationary, sheave of the secondary clutch. However, such locations limit the size that the fan can be and typically require that the fan be integrally formed in the respective sheave.

SUMMARY

In various embodiments, the present disclosure provides an off-road utility vehicle comprising a prime mover and a continuously variable transmission, wherein the transmission comprises a housing including an inner cover and an outer cover connectable to the inner cover to provide the housing having an interior chamber defined therein. The housing outer cover comprises a primary clutch dome defining a primary clutch chamber within the interior chamber of the housing, a secondary clutch dome defining a secondary clutch chamber within the interior chamber of the housing, and an air passage extending from the primary clutch dome at a proximal end to the secondary clutch dome at a distal end, the air passage structured and operable to direct air from the primary clutch chamber to the secondary clutch chamber.

In various other embodiments, the present disclosure provides an off-road utility vehicle comprising a prime mover structured and operable to generate torqued utilized to provide motive force for the vehicle and a continuously variable transmission. In various instances the continuously variable transmission comprises a housing that includes an inner cover, an outer cover connectable to the inner cover to provide the housing having an interior chamber defined therein. In various instances the housing outer cover comprises a primary clutch dome defining a primary clutch chamber within the interior chamber of the housing, a secondary clutch dome defining a secondary clutch chamber within the interior chamber of the housing, and an air passage extending from the primary clutch dome at a proximal end to the secondary clutch dome at a distal end, the air passage structured and operable to direct air from the primary clutch chamber to the secondary clutch chamber. In some embodiments, the housing further includes an air intake port disposed in the primary clutch dome. The continuously variable transmission further comprises a primary clutch assembly at least partially disposed within the primary clutch dome, and a secondary clutch assembly at least partially disposed within the secondary clutch dome.

In yet other embodiments, the present disclosure provides an off-road utility vehicle comprising a prime mover structured and operable to generate torqued utilized to provide motive force for the vehicle and a continuously variable transmission. In various instances the continuously variable transmission comprises a housing that includes an inner cover, an outer cover connectable to the inner cover to provide the housing having an interior chamber defined therein. In various instances the housing outer cover comprises a primary clutch dome defining a primary clutch chamber within the interior chamber of the housing, a secondary clutch dome defining a secondary clutch chamber within the interior chamber of the housing, an interstitial portion disposed between the primary clutch dome and the secondary clutch dome, and an air passage disposed below the interstitial portion and extending from a lower half of the primary clutch dome at a proximal end to lower half of the secondary clutch dome at a distal end. The air passage is structured and operable to direct air from the primary clutch chamber to the secondary clutch chamber. The primary clutch dome, the secondary clutch dome, and the air passage protrude outward and away from the housing interior chamber. In some embodiments, the housing further includes an air intake port disposed in the primary clutch dome. The continuously variable transmission further comprises a primary clutch assembly at least partially disposed within the primary clutch dome, and a secondary clutch assembly at least partially disposed within the secondary clutch dome.

While the present disclosure is primarily described with regard to an air induction cooled CVT for use in an off-road utility vehicle, it should be understood that the features of the CVT disclosed herein can be applied, within the scope of the disclosure, to other types of vehicles such as most lightweight vehicles that are not designated for use on roadways, e.g., maintenance vehicles, cargo vehicles, shuttle vehicles, golf carts, other all-terrain vehicles (ATVs), utility task vehicles (UTVs), recreational off-highway vehicles (ROVs), side-by-side vehicles (SSVs), worksite vehicles, buggies, motorcycles, watercrafts, snowmobiles, tactical vehicles, etc.

This summary is provided merely for purposes of summarizing various example embodiments of the present disclosure so as to provide a basic understanding of various aspects of the teachings herein. Various embodiments, aspects, and advantages will become apparent from the following detailed description taken in conjunction with the

accompanying drawings which illustrate, by way of example, the principles of the described embodiments. Accordingly, it should be understood that the description and specific examples set forth herein are intended for purposes of illustration only and are not intended to limit the scope of the present teachings.

DRAWINGS

The drawings described herein are for illustration purposes only and are not intended to limit the scope of the present teachings in any way.

FIG. **1** is a side view of a utility vehicle including an air induction cooled continuously variable transmission (CVT), in accordance with various embodiments of the present disclosure.

FIG. **2** is a schematic of a chassis, a prime mover and a drivetrain of the vehicle shown in FIG. **1**, in accordance with various embodiments of the present disclosure.

FIG. **3** is an isometric exploded view of the CVT shown in FIG. **1** operably coupled to an engine and gearbox of the vehicle shown in FIG. **1**, in accordance with various embodiments of the present disclosure.

FIG. **4** is a side view of a clutch assembly of the CVT shown in FIGS. **1** and **3**, in accordance with various embodiments of the present disclosure.

FIG. **5** is an isometric exploded view of the clutch assembly shown in FIG. **4**, in accordance with various embodiments of the present disclosure.

FIG. **6** is an isometric exploded view of the CVT shown in FIG. **1** operably coupled to an engine and gearbox of the vehicle shown in FIG. **1**, and having an air flow control housing outer cover, in accordance with various embodiments of the present disclosure.

FIG. **7** is an isometric view of the CVT housing with the air flow control housing outer cover shown in FIG. **6**, in accordance with various embodiments of the present disclosure.

FIG. **8** is an isometric view of an interior side of an air flow control housing outer cover, in accordance with various other embodiments of the present disclosure.

FIG. **9** an isometric view of an interior side of the outer cover shown in FIGS. **6** and **7**, in accordance with various embodiments of the present disclosure.

FIG. **10** is a view of an interior face of an inner cover of the housing shown in FIGS. **3** and **6** having an airfoil, in accordance with various embodiments of the present disclosure.

FIG. **11** is a view of the interior face of the housing outer cover shown in FIG. **3** having an airfoil, in accordance with various embodiments of the present disclosure.

FIG. **12** is a view of the interior face of the housing outer cover shown in FIG. **8** having an airfoil, in accordance with various embodiments of the present disclosure.

FIG. **13** is a view of the interior face of the housing outer cover shown in FIGS. **6**, **7** and **9** having an airfoil, in accordance with various embodiments of the present disclosure.

Corresponding reference numerals indicate corresponding parts throughout the several views of drawings.

DETAILED DESCRIPTION

The following description is merely exemplary in nature and is in no way intended to limit the present teachings, application, or uses. Throughout this specification, like reference numerals will be used to refer to like elements. Additionally, the embodiments disclosed below are not intended to be exhaustive or to limit the invention to the precise forms disclosed in the following detailed description. Rather, the embodiments are chosen and described so that others skilled in the art can utilize their teachings. As well, it should be understood that the drawings are intended to illustrate and plainly disclose presently envisioned embodiments to one of skill in the art, but are not intended to be manufacturing level drawings or renditions of final products and may include simplified conceptual views to facilitate understanding or explanation. As well, the relative size and arrangement of the components may differ from that shown and still operate within the spirit of the invention.

As used herein, the word "exemplary" or "illustrative" means "serving as an example, instance, or illustration." Any implementation described herein as "exemplary" or "illustrative" is not necessarily to be construed as preferred or advantageous over other implementations. All of the implementations described below are exemplary implementations provided to enable persons skilled in the art to practice the disclosure and are not intended to limit the scope of the appended claims.

Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs. The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms "a," "an," and "the" may be intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms "comprises," "comprising," "including," and "having," are inclusive and therefore specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. The method steps, processes, and operations described herein are not to be construed as necessarily requiring their performance in the particular order discussed or illustrated, unless specifically identified as an order of performance. It is also to be understood that additional or alternative steps can be employed.

When an element, object, device, apparatus, component, region or section, etc., is referred to as being "on," "engaged to or with," "connected to or with," or "coupled to or with" another element, object, device, apparatus, component, region or section, etc., it can be directly on, engaged, connected or coupled to or with the other element, object, device, apparatus, component, region or section, etc., or intervening elements, objects, devices, apparatuses, components, regions or sections, etc., can be present. In contrast, when an element, object, device, apparatus, component, region or section, etc., is referred to as being "directly on," "directly engaged to," "directly connected to," or "directly coupled to" another element, object, device, apparatus, component, region or section, etc., there may be no intervening elements, objects, devices, apparatuses, components, regions or sections, etc., present. Other words used to describe the relationship between elements, objects, devices, apparatuses, components, regions or sections, etc., should be interpreted in a like fashion (e.g., "between" versus "directly between," "adjacent" versus "directly adjacent," etc.).

As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. For example, A and/or B includes A alone, or B alone, or both A and B.

Although the terms first, second, third, etc. can be used herein to describe various elements, objects, devices, apparatuses, components, regions or sections, etc., these elements, objects, devices, apparatuses, components, regions or sections, etc., should not be limited by these terms. These terms may be used only to distinguish one element, object, device, apparatus, component, region or section, etc., from another element, object, device, apparatus, component, region or section, etc., and do not necessarily imply a sequence or order unless clearly indicated by the context.

Moreover, it will be understood that various directions such as "upper", "lower", "bottom", "top", "left", "right", "first", "second" and so forth are made only with respect to explanation in conjunction with the drawings, and that components may be oriented differently, for instance, during transportation and manufacturing as well as operation. Because many varying and different embodiments may be made within the scope of the concept(s) herein taught, and because many modifications may be made in the embodiments described herein, it is to be understood that the details herein are to be interpreted as illustrative and non-limiting.

Referring to FIGS. **1**, **2** and **3**, in various embodiments, the present disclosure provides an off-road utility vehicle **10** that generally includes a chassis or frame **14**, a pair of rear wheels **18** and a pair of front wheels **22** operationally connected to the chassis **14** and/or other structure of the vehicle **10**, and a passenger compartment **26**. The vehicle **10** can be any four-wheel drive or two-wheel drive lightweight vehicle that is not designated for use on roadways. For example, it is envisioned that the vehicle **10** can be a maintenance vehicle, cargo vehicle, shuttle vehicle, golf cart, other all-terrain vehicles (ATV), utility task vehicle (UTV), recreational off-highway vehicle (ROV), side-by-side vehicle (SSV), worksite vehicle, buggy, motorcycle, watercraft, snowmobile, tactical vehicle, etc. The passenger compartment **26** generally includes a dash console **30**, a steering wheel **34**, a floorboard (not shown, but understood), and a passenger seating structure **38**. The vehicle **10** additionally includes a prime mover **42** mounted to the chassis **14**, and a drivetrain **44** operationally connected to at least one of the front and/or rear wheels **22** and/or **18** and the prime mover **42**. The prime mover **42** is structured and operable to generate torque (e.g., motive force, e.g., power) utilized to provide motive force for the vehicle **10** via the drivetrain **44**. Although the prime mover **42** is primarily described herein as an internal combustion engine (ICE), it should be understood that the prime mover **42** can be an electric motor, a hybrid combination of an ICE and an electric motor, or any other suitable motor or engine and remain within the scope of the present disclosure.

In various embodiments, the drivetrain **44** includes an air induction cooled continuously variable transmission (CVT) **46** that is operably connected to the prime mover **42** to receive torque (e.g., motive force, e.g., power) from the prime mover **42**, and operably connected to at least one of the rear and front wheels **18** and **22** to deliver torque to at least one of the rear and front wheels **18** and **22**. In various embodiments, the CVT **46** can be operably connected to at least one of the rear wheel(s) **18** and the front wheel(s) **22** via one or more rear and/or front wheel axles **52** and/or **62** that are operably connected to the CVT **46**. Additionally, in various embodiments the CVT **46** can be operably connected to at least one of the rear and front wheels **18** and **22** via a first gearbox **50**. In such embodiments, the first gearbox **50** is operably connected to the CVT **46** and at least one rear and front wheel **18** and **22** is operably connected to the first gearbox **50** via one or more rear and/or front wheel axles **52** and/or **62** and/or a driveshaft **54**. For simplicity, the CVT **46** will be described herein as operably connected to at least one of the rear and front wheels **18** and **22** via the first gearbox **50**. The first gearbox **50** can be a torque transfer device such as a transmission and/or a differential and/or a transaxle, etc. For example, in various implementations, the first gearbox **50** can be a multi-speed gearbox and, in various instances, include a differential for distributing the torque to one or more of the wheels **18** and/or **22**.

In various embodiments, the CVT **46** is structured and operable to receive torque (e.g., motive force, e.g., power) generated by the prime mover **42** and controllably transfer the torque to the first gearbox **50**. Particularly, when transferring the torque to the first gearbox **50**, the CVT **46** is structured and operable to controllably vary the amount of torque delivered to the gearbox **50**. That is, the amount of torque delivered can controllably be increased, decreased and/or not changed via operation of the CVT **46**. The first gearbox **50** is structured and operable to transfer and distribute the torque to one or more of the wheels **18** and/or **22**. For example, in various embodiments, the first gearbox **50** can be operably connected to a rear axle **52** and structured and operable to transfer and distribute the torque output by the CVT **46** to at least one of the rear wheels **18**. In various other embodiments, in addition to transferring and distributing the torque to at least one of the rear wheels **18**, the first gearbox **50** can include a power take off (PTO) such that the first gearbox **50** can also transfer and distribute the torque output by the CVT **46** to at least one of the front wheels **22**. In such embodiments, the drivetrain **44** can include a driveshaft **54** and a second gearbox (or differential) **58**, wherein the driveshaft **54** is operably connected at one end to the CVT **46** or the first gearbox **50** via the PTO and operably connected at the opposing end to the second gearbox **58**. The second gearbox **58** is structured and operable to transfer and distribute the torque output by the CVT **46** to one or more of the front wheels **22** via a front axle **62**.

Hence, in various embodiments, the drivetrain **44** can be configured to provide a 4-wheel drive (4WD) vehicle or a 2-wheel drive (2WD) vehicle, and remain within the scope of the present disclosure. In various embodiments in which the drivetrain **44** is configured to provide a 2WD vehicle, the vehicle **10** can be driven by the rear wheels **18** (e.g., a rear wheel drive vehicle) or by the front wheels **22** (e.g., a front wheel drive vehicle). In some embodiments in which the vehicle **10** can be configured as a 4WD vehicle, the vehicle **10** can be selectively operated in two or more drive modes, such as a 2WD mode and a 4WD mode, through actuation of a switch or other user input device that can be disposed on the instrument panel **30**, or elsewhere.

Additionally, although the prime mover **42** and CVT **46** are illustrated, by way of example, in the various figures to be at least partially disposed rearward of a longitudinal center of the vehicle **10**, it is envisioned that the prime mover **42** and CVT **46** can be disposed anywhere along a longitudinal axis of the vehicle **10** and remain within the scope of the present disclosure. For example, in various embodiments, the prime mover **42** and/or the CVT **46** can be disposed forward of the longitudinal center of the vehicle **10**, e.g., forward of a forward most part of the seating structure **38**. Furthermore, although the prime mover **42**, the CVT **46**, and the first gearbox **50** are shown, by way of example, to be directly connected with each other, it should be understood that the drivetrain **44** can include one or more driveshafts (such as driveshaft **54**) that operably interconnect one or more of the prime mover **42**, the CVT **46**, the first gearbox **50** and/or the second gearbox **58** based on the respective location of the prime mover **42** and CVT **46** along the vehicle longitudinal axis, and the respective 2WD or 4WD configuration of the drivetrain **44**.

As used herein, the word "forward" and the phrase "forward of" are used to describe the direction from a named component or structure toward the front of the vehicle **10**. For example, the statement that the prime mover **42** is mounted to the chassis **14** "forward of" the longitudinal center means the prime mover **42** is mounted to the chassis **14** within an area that extends from the longitudinal center of the chassis **14** to the front of the chassis **14** at the front of the vehicle **10** (e.g., adjacent the front wheels **22** positioned at the front of the vehicle **10** in the illustrated embodiment). Similarly, as used herein, the word "rearward" and the phrase "rearward of" are used to describe the direction from a named component or structure toward the rear of the vehicle **10**. For example, the statement that the prime mover **42** is mounted to the chassis **14** "rearward of" the longitudinal center means the prime mover **42** is mounted to the chassis **14** within an area that extends from the longitudinal center of the chassis **14** to the rear of the chassis **14** at the rear of the vehicle **10** (e.g., adjacent the rear wheels **18** positioned at the rear of the vehicle **10** in the illustrated embodiment).

Referring now to FIG. **3**, the CVT **46** generally includes a primary clutch assembly **70**, a secondary clutch assembly **74**, a drive belt **78** that operably connects the primary clutch assembly **70** to the secondary clutch assembly **74** and housing **80**. The housing **80** is structured to enclose the primary clutch assembly **70**, secondary clutch assembly **74**, and drive belt **78** within an interior chamber **82** of the housing **80**. The housing **80** protects the primary clutch assembly **70**, the secondary clutch assembly **74**, the drive belt **78** from water, mud, dirt and other debris present in the ambient (exterior) environment. In various embodiments, the housing **80** comprises an inner cover **80**A and an outer cover **80**B that is connectable to the first cover **80**A to define the interior chamber **82**. The first cover **80**A includes a torque/power input opening **84** that is sized and shaped to allow an output shaft **86** of the prime mover **42** to extend therethrough. The first cover **80**A additionally includes a torque/power output opening **90** that is sized and shaped to allow the secondary clutch assembly **74** to be operably connected, (e.g., via the first gearbox **50**) to at least one of the rear and/or front axles **52** and/or **62** such that torque/power output by the secondary clutch assembly **74** is delivered to at least one of the rear and/or front wheels **18** and/or **22**. For example, in various instances, the torque/power output opening **90** can be sized and shaped to allow an input shaft **94** of the first gearbox **50** to extend therethrough.

The primary clutch assembly **70** is operably connectable to the prime mover output shaft **86** such that torque/power generated by the prime mover **42** will be delivered to the primary clutch assembly **42**, whereafter, via the drive belt **78**, the primary clutch assembly **70** will transfer torque/power to the secondary clutch assembly **74**. Thereafter, the torque/power received at the secondary clutch assembly **74** will be delivered to at least one of the rear and/or front axles **52** and/or **62**. For example, in various embodiments wherein the drivetrain **44** includes the first gearbox **50**, the secondary clutch assembly **74** can transfer the received torque/power to the first gearbox **50**, via the first gearbox input shaft **94**, and consequently to the rear and/or front axles **52** and/or **62**.

In various embodiments, the primary clutch assembly **70** is structured and operable to deliver a continuously variable torque to the secondary clutch assembly **74**. That is, the primary clutch assembly **70** is structured and operable to continuously variably increase, maintain unchanged, and decrease the torque/power received from the prime mover output shaft **86** when transferring the torque/power to the secondary clutch assembly **74**. Put another way, a torque/power transfer ratio of the torque/power received by the primary clutch assembly **70** from the prime mover **42** versus the torque/power delivered to the secondary clutch assembly **74** from the primary clutch assembly **70** can be continuously varied via operation of the primary clutch assembly **70**.

Referring now to FIGS. **3**, **4** and **5**, in various embodiments, one or both of the primary and secondary clutch assemblies **70** and/or **74** can comprise the following components that are structured and operable to function in the manner described below. Particularly, in various embodiments, one or both of the primary and secondary clutch assemblies **70** and/or **74** can comprise an intake fan **98** as described below. However, for simplicity and clarity, by way of example, only the primary clutch assembly **70** will be described to comprise the intake fan **98** and the operation and functionally of the intake fan **98** will be described, by way of example, only with regard to the primary clutch assembly **70**. However, it will be easily and readily understood by one skilled in the art that the description herein relating to the intake fan **98** with regard to embodiments of the primary clutch assembly **70** is merely an example, and such description is equally applicable with regard to embodiments of the secondary clutch **74** and is wholly within the scope of the present disclosure.

In various embodiments, the primary clutch assembly **70** comprises a clutch post **102**, a stationary (or static) sheave **106** that is fixedly mounted to the clutch post **102**, and a movable (or dynamic) sheave **110** that is movably mounted to the clutch post **102**. The clutch post **102**, and hence the primary clutch assembly **70**, is fixedly connectable to the prime mover output shaft **86** via a clutch bolt **114** such that the primary clutch assembly **70** will rotate in accordance with rotation of the output shaft **86** and will thereby receive the torque/power generated by the prime mover **42**. More particularly, the movable sheave **110** is structured and operable to rotate with the output shaft/clutch post **86**/**102** and simultaneously controllably move axially along the clutch post **102** in the X^+ and X^- directions. The stationary sheave **106** includes a beveled front face **116**. Similarly, the movable sheave **110** comprises a beveled front face **118** that is disposed opposite (e.g., disposed face to face) the stationary sheave beveled front face **116**. The movable sheave **110** further includes a linear movement mechanism **122** that is structured and operable to controllably move the movable sheave **110** axially along the clutch post **102** in the X^+ and X^- directions. A V-shaped channel **126** is formed between the opposing beveled front faces **116** and **118** of the stationary and movable sheaves **106** and **110**, and the drive belt **78** is disposed within the V-shaped channel **126**. Controlled axial movement of the movable sheave **110** in the X^+ and X^- directions along the clutch post **102**, via the linear movement mechanism **122**, varies a width of the V-shaped channel **126**. The controlled varying of the channel **126** varies a diameter, or radial distance from the clutch post **102**, at which the drive belt **78** travels within the V-shaped channel **126**, which in turn various the torque transfer ratio of the primary clutch assembly **70** to the secondary clutch assembly **74**. Therefore, the torque/power output by the secondary clutch assembly **74** (e.g., the torque/power output by the secondary clutch assembly **74** to the first gearbox **50**) can be controllably varied by the controlled linear movement of the movable sheave **110**.

In various embodiments, the axial movement of the movable sheave **110** along the clutch can be controlled by a vehicle controller and/or a CVT controller (not shown). Such a CVT controller can be a controller that is communicatively connected to, or integrated as part of, a main vehicle controller that is typically understood to be an embedded system that controls one or more of electrical systems and/or subsystems the vehicle **10**. Generally, such a CVT controller can be any suitable hardware and/or software (e.g., software instructions stored on a non-transitory computer readable medium that can be read and performed by one or more processors) based controller that is structured and operable to control operation of the CVT **46** as described herein. For example, it is envisioned that such a CVT controller can comprise one or more, or be part of, application specific integrated circuit(s) (e.g., ASIC(s)), combinational logic circuit(s); field programmable gate array(s) (FPGA); processor(s) (shared, dedicated, or group) that execute software code; and/or other suitable hardware components that provide the CVT functionality described herein and remain within the scope of the present disclosure.

As described above, by way of example, in various embodiments, the primary clutch assembly **70** includes the intake fan **98**. More particularly, in such embodiments, the intake fan **98** is fixedly mounted to the clutch post **102** opposite a back face **130** of the movable sheave **110** (e.g., disposed face to face, e.g., disposed with movable sheave back face **130** facing fan back face **134**) such that the intake fan **98** is independent, separate, distinct and spaced apart from the back face **130** of the movable sheave **110**. More specifically, the intake fan **98** is an independent, separate, distinct component of the primary clutch assembly **70** and is independent, separate and distinct from both the stationary and movable sheaves **106** and **110**. The intake fan **98** can be mounted to the clutch post **102** in any suitable manner. For example, in various embodiments, the intake fan **98** can be compressed between a lock washer **128**, a retaining washer **132** and a head washer **136** as the clutch bolt **114** is tightened to fixedly connect the intake fan **98** to the clutch post **102**. The retaining washer **132** and head washer **136** allows most or substantially all the compressive force to transfer through the lock washer **128**, head washer **136**, and retaining washer **132** and not through the intake fan **98**. In various instances, the retainer washer **132** is structured to ensure that the intake fan **98** is centered on the clutch post **102**.

In various embodiments, a slack section **102**A of the clutch post **102** generally extends beyond the back face **130** of the movable sheave **110**. As described above, during operation of the primary clutch assembly **70**, the movable sheave **110** controllably moves, or transitions, (via operation of the linear movement mechanism **122**) along the clutch post **102** in the X^- and X^+ directions to adjust the space between the beveled front faces **116** and **118** to controllably adjust the torque/power transferred to the secondary clutch assembly **74**. Moreover, as the moveable sheave **110** moves/transitions in the X^- and X^+ directions along the clutch post **102**, a length L of the slack section **102**A will increase and decrease. The length L is defined to be the distance between the back face **130** of the movable sheave **110** and a back face **134** of the intake fan **98**. For example, the length L of the slack section **102**A will be a maximum length when the movable sheave **110** is moved/transitioned as far in the X^- direction toward the stationary sheave **106** as the operational limits of the primary clutch assembly allow. Conversely, the length L of the slack section **102**A will be a minimum length when the movable sheave **110** is moved/transitioned as far in the X^+ direction away from the stationary sheave **106** as the operational limits of the primary clutch assembly allow.

Still more particularly, the clutch post **102** is structured to have a length (not shown but understood) such that the length L of the slack section **102**A allows the moveable sheave **110** to move as far in the X^+ direction away from the stationary sheave **106** as the operational limits of the primary clutch assembly allow without the back face **130** of the moveable sheave **110** contacting the back face **134** of the intake fan **98**. In various embodiments, the slack section of the clutch post **102** can be between 1.0 inches and 2.50 inches. Furthermore, in various embodiments the minimum length of the clutch post slack length **102**A (e.g., the length of the slack length L when the movable sheave **110** is moved/transitioned as far in the X^+ direction away from the stationary sheave **106** as the operational limits of the primary clutch assembly allow) can be between 0.05 and 0.50 inches. Hence, the length of clutch post **102** and the length L of the clutch post slack section **102**A are such that the primary clutch (e.g., the stationary and movable sheaves **106** and **110**) can operate (e.g., the movable sheave **110** can controllably move/transition along the clutch post **102** the X^- and X^+ directions) without the movable sheave **110** contacting the intake fan **98**. Particularly, the length of clutch post **102** and the length L of the clutch post slack section **102**A are such that the location and orientation of the intake fan **98** within the CVT housing **80** is generally fixed and does not change. More particularly, the location and orientation of the intake fan **98** relative to an interior face **138** of the housing outer cover **80**B is generally fixed and does not change. Still more particularly, the length of clutch post **102** and the length L of the clutch post slack section **102**A are such that an outer face **142** of the intake fan **98** is generally a fixed distance D from the interior face **138** of the outer housing cover **80**B.

The intake fan **98** comprises a plurality of fins **146** that define the outer face **142** of the intake fan **98**. The size, shape and dimensions of the intake fan **98** can be any desired size, shape and dimensions suitable for desirably cooling the respective CVT **46** when operated in the respective application and environment. Additionally, the size, shape, dimensions, number and configuration of the fins **146** can be any desired size, shape, dimensions, number and configuration suitable for desirably cooling the respective CVT **46** when operated in the respective application and environment.

In various embodiments, the housing outer cover **80**B includes an air intake port **150** that fluidly connects the ambient air from an ambient environment external to the housing **80** with the interior chamber **82** of the housing **80**. The air intake port **150** is located in the housing outer cover **80**B such that the intake port **150** is generally opposite (e.g., disposed face to face) and aligned with a center of the intake fan **98** and an inner radius of the fins **146**, (e.g., the intake port **150** is generally opposite (e.g., disposed face to face) and aligned with a head of the clutch bolt **114**). As described above, the length of clutch post **102** and the length L of the clutch post slack section **102**A are such that the outer face **142** of the intake fan **98** is the generally fixed distance D from the interior face **138** of the outer housing cover **80**B. Moreover, the distance D has a length such that the space between the intake fan outer face **142** and the outer housing cover interior face **138** defines a low pressure gap **148**. The distance D will also be referred to herein as the width of the low pressure gap **148**. The width D of the low pressure gap **148** has a length such that when the intake fan **98** is rotated, via rotation of the clutch post **102** by the prime mover output shaft **86**, an area of low pressure is generated within a low pressure gap **148**. The area of low pressure in turn generates a vacuum effect, or suction, at the air intake port **150** and within the low pressure gap **148**, whereby ambient air will be drawn into the housing interior chamber **82** at or near the center of the intake fan outer face **142**. The ambient air drawn into the center of the intake fan **98** is then forced radially outward by the fins **146** into the interior chamber **82**, thereby generating airflow within the interior chamber **82** that cools the primary and secondary clutch assemblies **70** and **74** and the drive belt **78**, as described below. In various embodiments, the width D of the low pressure gap **148** can be between approximately 0.010 and 0.30 inches, for example, between approximately 0.10 inches to 0.20 inches, e.g., between approximately 0.050 and 0.10.

As used herein, the term 'vacuum effect' will be understood to mean the suction or drawing of air from a first area (e.g., the ambient environment) to a second area (e.g., the interior chamber **82** of the housing **80**) caused by creating a lower pressure within the second area (e.g., within the low pressure gap **148**) than exists at the first area (e.g., the ambient environment). For example, due to the structure of the intake fan **98** and width D of the low pressure gap **148** (e.g., location of the intake fan outer face **142** relative to the outer cover interior face **138**), rotation of the intake fan **98** creates a lower air pressure within the low pressure gap **148** than is present in the ambient environment external to the housing **80**, thereby generating a vacuum effect that will draw air from the ambient environment into the housing interior chamber **82** via the air intake port **150**.

The housing **80** additionally includes an air exhaust outlet **154** that fluidly connects the interior chamber **82** with the ambient environment. It is envisioned that the exhaust outlet **154** can be formed within the inner cover **80**A, within the outer cover **80**B, or a combination thereof when the inner and outer covers **80**A and **80**B are connected. Accordingly, as described above, rotation of the intake fan **98** generates a vacuum, or suction, at the air intake port **150** that draws cool ambient air into the housing interior chamber **82**. Subsequently, the rotation of the intake fan **98** (e.g., rotation of the fins **146**) disperses the air radially outward to the distal ends, or outer radius, of the fins **146**. Thereafter, rotation of the intake fan **98**, combined with rotation of the primary and secondary clutch assemblies **70** and **74** and rotation of the drive belt **78**, swirls, mixes, and circulates the air through the interior chamber **82**, around and across the primary and secondary clutch assemblies **70** and **74** and the drive belt **78**, thereby extracting heat from and thermally cooling the primary and secondary clutch assemblies **70** and **74** and the drive belt **78**. The heated circulated air is then exhausted from the interior chamber **82** out into the ambient environment through the exhaust outlet **154**.

Referring now to FIGS. **4** and **8**, in various embodiments, the housing **80** can be formed and structured to control the air flow within interior chamber **82**. For example, in various embodiments, the housing outer cover **80**B can comprise a clutch dome **158** that defines a clutch alcove **162** within the interior chamber **82** of the housing **80**. In such instances, at least the intake fan **98** of the primary clutch assembly **70** will be disposed within the clutch alcove **162**, and the interior face **138** of the housing **80** comprises an interior face **138**A of a top **166** of the clutch dome **158**. Moreover, in such embodiments, the intake fan **98** is disposed within the clutch alcove **162** such that the outer face **142** of the intake fan **98** is located opposite the interior face **138**A of the clutch dome top **166** when the CVT **46** is assembled. Therefore, the low pressure gap **148** is defined between the intake fan outer face **142** and the clutch dome top interior face **138**A, whereby air is drawn into the housing **80** at the center of the intake fan outer face **142** when the intake fan **98** is rotated. In various embodiments, the housing outer cover **80**B can additionally include an air duct **170** fluidly connected to the clutch dome alcove **162**, whereby air can be directed and guided from the clutch dome alcove **162**, through the air duct **170** to the area of the interior chamber at or near the end of the housing **80** that is opposite the clutch dome **158**.

Hence, ambient air drawn into the clutch dome alcove **162**, via the air intake port **150**, intake fan **98** and low pressure gap **148**, can be circulated around and through the clutch alcove **162**, then forced through air duct **170** (via the intake fan **98**) to the opposing end of the interior chamber **82**. Consequently, a portion of the air flow will be exhausted back to the ambient environment, via the exhaust outlet **154**, and a remaining portion will be circulated, swirled, and/or mixed through the interior chamber **82**, around and across the primary and secondary clutch assemblies **70** and **74** and the drive belt **78**, whereafter another portion will be will be exhausted back to the ambient environment. Thereafter, rotation of the intake fan **98** will continue to draw ambient air into the primary clutch alcove **162**, circulate the air though the interior chamber **82**, and exhaust air back into the ambient environment, thereby cooling the primary and secondary clutch assemblies **70** and **74** and the drive belt **78**. In various embodiments, the secondary clutch assembly **74** can include a secondary clutch fan **196**, as described below, that aids in the circulation of the air through the interior chamber **82**.

Referring now to FIGS. **4**, **6**, **7** and **9**, as described above, the CVT **46** comprises the primary clutch assembly **70** and the secondary clutch assembly **74**, wherein the primary clutch assembly **70** includes the stationary sheave **106** and the movable sheave **110**. In various embodiments, the secondary clutch assembly **74** comprises a stationary sheave **174** and a movable sheave **178**. Additionally, in various embodiments, the clutch dome **158**, described above, can be a primary clutch dome (referred to hereafter as the primary clutch dome **158**) and the clutch alcove **162** can be a primary clutch alcove (referred to hereafter as the primary clutch alcove **162**). In such embodiments, the primary clutch assembly **70** includes the intake fan **98**, as described above, and at least the intake fan **98** is disposed within the primary clutch alcove **162** such that the outer face **142** of the intake fan **98** is located opposite the interior face **138**A of the primary clutch dome top **166** when the CVT **46** is assembled, thereby defining the low pressure gap **148**.

In various instances of such embodiments, the housing outer cover **80**B can further comprise a secondary clutch dome **182** that defines a secondary clutch alcove **186** within the interior chamber **82** of the housing **80**, wherein at least a portion the stationary sheave **174** of the secondary clutch assembly **74** is disposed within the secondary clutch alcove **186**. In various embodiments, the secondary clutch assembly stationary sheave **174** can comprise a plurality of vanes, or fins, **194** integrally formed with or disposed on an outer side of the stationary sheave **174**, thereby by providing a secondary clutch fan **196**. In various instances, the vanes **194** extend radially outward from a center hub **202** of the secondary clutch assembly stationary sheave **174** such that the secondary clutch fan **196** has an annular shape and configuration wherein the vanes **194** define an annular outer face **198** of the annular secondary clutch fan **196**. The secondary clutch fan **196** assists in cooling the primary clutch assembly **70**, secondary clutch assembly **74** and drive belt **78** by swirling, mixing, and circulating the air through the interior chamber **82**, via rotation of the secondary clutch assembly **74**, thereby extracting heat from and thermally cooling the primary and secondary clutch assemblies **70** and **74** and the drive belt **78**.

Moreover, in various embodiments, the secondary clutch fan **196** assists in generating the air flow through the housing interior chamber **82**, as described below. Particularly, in various embodiments, the housing outer cover **80**B comprises an air duct **206** formed between the primary clutch dome **158** and the secondary clutch dome **182**. The air duct **206** is fluidly connected to the primary clutch alcove **162** at a proximal end **206**A and fluidly connected to the secondary clutch alcove **186** at a distal end **206**B. Therefore, the air duct **206** fluidly connects the primary clutch alcove **162** to the secondary clutch alcove **186**. The air duct **206** guides and controls the air flow within the interior chamber **82**. Particularly, the air flow is initiated at the intake port **150** by the intake fan **98** and low pressure gap **148** drawing the ambient air into the primary clutch alcove **162** at the center of the intake fan **98** (as described above), then the fins **146** force the air radially outward toward the distal ends of the fins **146** and into the primary clutch alcove **162**. The location of the intake fan **98** within the primary clutch alcove **162** (as described above) and the shape/structure of the primary clutch alcove **162** direct and force the air flowing from the fins **146** into the primary clutch alcove **162**, whereafter the air can be circulated around the primary clutch alcove **162** and forced into the air duct **206** toward the secondary clutch alcove **186**. In various instances, the secondary clutch fan **196** is disposed within the secondary clutch alcove **186** having the outer face **198** of the secondary clutch fan **196** located opposite an interior face **138**B of the secondary clutch dome top **190** such that a vacuum is generated in the space between the secondary clutch fan outer face **198** and the secondary clutch dome top interior face **138**B. This vacuum will also draw air from the primary clutch alcove **162**, through the air duct **206**, and into the secondary clutch alcove **186**.

Therefore, the air is forced into and drawn through the duct **206** via the intake fan **98** and the secondary fan **198**, respectively. Consequently, a portion of the air flow will be exhausted back to the ambient environment, via the exhaust outlet **154**, and a remaining portion will be circulated around and within the secondary clutch alcove **186**, and circulated, swirled, and/or mixed through the interior chamber **82**, around and across the primary and secondary clutch assemblies **70** and **74** and the drive belt **78**. Thereafter, rotation of the intake fan **98** and the secondary clutch fan **196** will continue to draw ambient air into the primary clutch alcove **162**, direct the air into the secondary clutch alcove **186**, circulate the air though the interior chamber **82**, and exhaust air back into the ambient environment, thereby cooling the primary and secondary clutch assemblies **70** and **74** and the drive belt **78**.

Referring now to FIGS. **6**, **7** and **9**, in various embodiments, the distal end **206**B of the air duct **206** is fluidly connected to the secondary clutch alcove **186** and terminates near the center hub **202** of the stationary sheave **174** of the secondary clutch assembly **74**. Accordingly, air passing through the air duct **206** from the primary clutch alcove **162** to the secondary clutch alcove **186** will be directed toward the center hub **202** of the stationary sheave **174** of the secondary clutch assembly **74**, and more particularly toward the proximal or radially inner ends of the vanes **194**. Therefore, the air forced and drawn through the air duct **206** will be directed into the center of the annular secondary clutch fan **196** such that at least a majority (e.g., 80% to 100%) of the surface area of at least one face of each vane **194** will be utilized to force the air radially outward from the center hub **202** to distal ends of the vanes **194**. Utilizing at least a majority of the surface area of at least one face of each vane **194** will increase the velocity, volume, flow rate, circulation and thermal cooling efficiency of the air flow generated by the intake fan **98** and secondary clutch fan **196** described above.

Referring now to FIGS. **6**, **7**, **8** and **9**, the air duct **170**/**206** has a height H^P at the proximal end **170**A/**206**A and a height H^D at the distal end **170**B/**206**B. In various embodiments, the proximal end height H^P can be greater than the distal end height H^D, thereby causing the air flowing through the air duct **170**/**206** to have a greater velocity and flow rate at the distal end **170**B/**206**B than at the proximal end **170**A/**206**A. Particularly, the air flow exiting the air duct **170**/**206** will have a greater velocity and flow rate than the air entering the air duct **170**/**206**, thereby increasing the velocity, volume, flow rate, circulation and thermal cooling efficiency of the air flow through the interior chamber **82**. Additionally, the air duct **170**/**206** has a width W^P at the proximal end **170**A/**206**A and a width W^D at the distal end **170**B/**206**B. In various embodiments, the proximal end width W^P is greater than the distal end width W^D, thereby causing the air flowing through the air duct **170**/**206** to have a greater velocity and flow rate at the distal end **170**B/**206**B than at the proximal end **170**A/**206**A. Particularly, the air flow exiting the air duct **170**/**206** will have a greater velocity and flow rate than the air entering the air duct **170**/**206**, thereby increasing the velocity, volume, flow rate, circulation and thermal cooling efficiency of the air flow through the interior chamber **82**. In various embodiments, both the proximal end height H^P and width W^P can be greater than the distal end height H^D and width W^D.

Referring now to FIGS. **10**, **11**, **12** and **13**, in various embodiments, the housing **80** can comprise an internal airfoil **210** disposed between the primary and secondary clutch assemblies **70** and **74**. The airfoil **210** comprises one or more walls that extend from an interior face **214** of the inner housing cover **80**A to the interior face **138** of the housing outer cover **80**B. The airfoil **210** can be connected to, and/or integrally form with, the housing inner cover interior face **214** and/or the housing outer cover interior face **138**. The airfoil **210** directs the air flow between the area of the interior chamber **82** that is near and/or surrounds the primary clutch assembly **70** and the area of the interior chamber **82** that is near and/or surrounds the secondary clutch assembly **74** to eliminate, or substantially reduce, swirling air, and turbulence from occurring in the area of the interior chamber **82** between the primary and second clutch assemblies **70** and **74**.

In various embodiments, the housing inner cover **80**A can have a first portion **210**A (e.g., a first half) of the airfoil **210** extending outward from the interior face **214** between the primary and secondary clutch assemblies **70** and **74**, and the housing outer cover **80**B can have a second portion **210**B (e.g., a second half) of the airfoil **210** extending outward from the interior face **138** between the primary and secondary clutch assemblies **70** and **74**. In various instances, the walls of first portion **210**A can align with and contact and the walls of the second portion **210**B when the housing inner and outer covers **80**A and **80**B are connected to form the housing **80** such that air circulating within the interior chamber **82** cannot flow between the first and second portions **210**A and **210**B, but rather is directed to flow around the airfoil **210** in a more direct path between the primary and secondary clutch assemblies **70** and **74**. In various other instances, the walls of first portion **210**A can overlap the walls of the second portion **210**B, or vice-versa, when the housing inner and outer covers **80**A and **80**B are connected to form the housing **80** such that air circulating within the interior chamber **82** cannot flow between the first and second portions **210**A and **210**B, but rather is directed to flow around the airfoil **210** in a more direct path between the primary and secondary clutch assemblies **70** and **74**.

In various embodiments, the first and second portions **210**A and **210**B can be structured such that one or more of the walls, or sections of one or more of the walls, of each of the airfoil first and second portions **210**A and **210**B extend from the inner faces **214** and **138** of the respective housing inner and outer covers **80**A and **80**B across the interior chamber **82** and contact the opposing inner face **138** and **214**, when the housing inner and outer covers **80**A and **80**B are connected to form the housing **80**. In such embodiments, the walls, or sections of the airfoil walls extending from the housing inner cover interior face **214** will contact and/or overlap the walls, or sections of the airfoil walls extending from the housing outer cover interior face **138**, or vice-versa, when the housing inner and outer covers **80**A and **80**B are connected to form the housing **80** such that air circulating within the interior chamber **82** cannot flow between any section of the first and second portions **210**A and **210**B, but rather is directed to flow around the airfoil **210** in a more direct path between the primary and secondary clutch assemblies **70** and **74**. In various other embodiments, the entire airfoil **210** can extend from the interior face **214** of the housing inner cover **80**A such that the walls of the airfoil **210** contact the inner face **138** of the housing outer cover **80**B when the housing inner and outer covers **80**A and **80**B are connected to form the housing **80**. Alternatively, in various embodiments, the entire airfoil **210** can extend from the interior face **138** of the housing outer cover **80**B such that the walls of the airfoil **210** contact the inner face **214** of the housing inner cover **80**A when the housing inner and outer covers **80**A and **80**B are connected to form the housing **80**.

As described above, the airfoil **210** is sized and shaped to direct the air flow between the area of the internal chamber **82** that is near and/or surrounds the primary clutch assembly **70** and the area of the internal chamber **82** that is near and/or surrounds the secondary clutch assembly **74** to eliminate, or substantially reduce, swirling air, and turbulence from occurring in the area of the internal chamber **82** between the primary and second clutch assemblies **70** and **74**. Particularly, the air flow is initiated at the intake port **150** by the intake fan **98** and low pressure gap **148** drawing the ambient air into the housing interior chamber **82** (e.g., into the primary clutch alcove **162**) at the center of the intake fan **98**, whereafter the air can be circulated around the primary clutch assembly **70**, (e.g., around the clutch alcove **162**) and forced toward the secondary clutch assembly **74** at the opposing end of the interior chamber **82** (e.g., forced into the air duct **170** toward the secondary clutch assembly **74** at the opposing end of the interior chamber **82**) or (e.g., forced into the air duct **206** and into the secondary clutch alcove **186**). The air will then circulate around the secondary clutch assembly **74** (e.g., circulate within the secondary clutch alcove **186** and around the secondary clutch assembly **74**). Thereafter, a portion of the air flow will be exhausted back to the ambient environment, via the exhaust outlet **154**, and a remaining portion will be directed back toward the primary clutch assembly **74** (e.g., directed back toward the primary clutch alcove **162** and primary clutch assembly **70**) in a substantially direct path via the airfoil **210**. Subsequently, the air returning in the substantially direct path from secondary clutch area of the interior chamber **82** will mix with air being drawn into the housing interior chamber (e.g., being drawn into the primary clutch alcove **162**), via the intake port **150**. The combined fresh and recirculated air will then be circulated around the primary clutch assembly **70**, (e.g., around the clutch alcove **162**) and forced toward the secondary clutch assembly **74** at the opposing end of the interior chamber **82**, as described above, whereafter a portion thereof will be exhausted and a portion recirculated, as described above, thereby extracting heat from and thermally cooling the primary and secondary clutch assemblies **70** and **74** and the drive belt **78**.

Hence the airfoil **210** will direct the air within the interior chamber **82** to flow in a substantially direct path from the area surrounding the primary clutch assembly **70**, along the area in which the drive belt is disposed, to the area surrounding secondary clutch assembly **74**, and from the area surrounding the secondary clutch assembly **74**, along the area in which the drive belt is disposed, back to the area surrounding the primary clutch assembly **70**. Moreover, the airfoil **210** will prevent the air flow from swirling, mixing and/or causing turbulence within the middle or central area of the interior chamber **82** between the primary and secondary clutch assemblies **70** and **74**, thereby increasing the velocity, volume, flow rate, circulation and thermal cooling efficiency of the air flow. The airfoil **210** can have generally any desired shape and size suitable for directing the airflow within the interior chamber **82** as described above. For example, as illustrated by way of example in FIGS. **10**, **11**, **12** and **13**, in various embodiments the airfoil **210** can have an open or closed elongated C-shape, wherein the airfoil **210** has length L that substantial spans the area within the interior chamber **82** between the primary and secondary clutch assemblies **70** and **74**. For example, the airfoil **210** can have a length L that positions a first end of the airfoil **210** nearly in contact with the stationary and movable sheaves **106** and **110** of the primary clutch assembly **70** (e.g., the first end is approximately 0.10 to 0.25 inches away from stationary and movable sheaves **106** and **110** of the primary clutch assembly **70**), and positions an opposing second end of the airfoil **210** nearly in contact with the stationary and movable sheaves **174** and **178** of the secondary clutch assembly **74** (e.g., the second end is approximately 0.10 to 0.25 inches away from stationary and movable sheaves **174** and **178** of the second clutch assembly **74**).

The description herein is merely exemplary in nature and, thus, variations that do not depart from the gist of that which is described are intended to be within the scope of the teachings. Moreover, although the foregoing descriptions and the associated drawings describe example embodiments in the context of certain example combinations of elements and/or functions, it should be appreciated that different combinations of elements and/or functions can be provided by alternative embodiments without departing from the scope of the disclosure. Such variations and alternative combinations of elements and/or functions are not to be regarded as a departure from the spirit and scope of the teachings.

What is claimed is:

1. An off-road utility vehicle, said vehicle comprising:

a prime mover; and

a continuously variable transmission comprising a housing, wherein the housing comprises:

an inner cover; and

an outer cover connectable to the inner cover to provide the housing having an interior chamber defined therein, the housing outer cover comprising:

a primary clutch dome formed entirely in the outer cover and defining a primary clutch chamber within the interior chamber of the housing;

a secondary clutch dome formed entirely in the outer cover and defining a secondary clutch chamber within the interior chamber of the housing; and

an air passage formed entirely in the outer cover and having a proximal end and a distal end, the air passage extending from the primary clutch dome at the proximal end and connecting to the secondary clutch dome at the distal end, the air passage structured to direct air from the primary clutch chamber to the secondary clutch chamber.

2. The vehicle of claim **1**, wherein the continuously variable transmission further comprises:

a primary clutch assembly at least partially disposed within the primary clutch dome, the primary clutch assembly including a fan; and

a secondary clutch assembly at least partially disposed within the secondary clutch dome,

wherein the fan of the primary clutch assembly is configured to draw air into the primary clutch dome when the primary clutch assembly is rotating.

3. The vehicle of claim **2**, wherein the secondary clutch assembly includes a fan, and wherein the air passage is configured to allow air to be drawn from the primary clutch chamber into the secondary clutch chamber by the secondary clutch assembly fan when the secondary clutch assembly is rotating.

4. The vehicle of claim **1**, wherein the transmission housing includes an interstitial portion disposed between the primary clutch dome and the secondary clutch dome,

wherein the primary clutch dome, the secondary clutch dome, and the entire air passage protrude outward and away from the interstitial portion, and

wherein the air passage is positioned along a lower portion of the interstitial portion and extends from a lower half of the primary clutch dome at the proximal end and connects to a lower half of the secondary clutch dome at the distal end.

5. The vehicle of claim **4**, wherein the primary clutch dome protrudes outward and away from the interstitial portion a first distance and the secondary clutch dome protrudes outward and away from the interstitial portion a second distance, wherein the first distance is greater than the second distance, and

wherein the proximal end of the air passage extending from the primary clutch dome protrudes outward and away from interstitial portion a greater distance than the distal end of the air passage connecting to the secondary clutch dome.

6. The vehicle of claim **4**, wherein the inner cover includes at least a portion of an exhaust air outlet disposed along an upper portion of the inner cover adjacent the secondary clutch dome.

7. The vehicle of claim **6**, wherein the housing includes a forward end and a rearward end, wherein the primary clutch dome includes a forward side disposed along the forward end of the housing and a rearward side connected to the interstitial portion, wherein the secondary clutch dome includes a forward side connected to the interstitial portion and a rearward side disposed along the rearward end of the housing, and wherein fresh air is only introduced to the housing forward of the rearward side of the primary clutch dome and exhaust air is only exhausted from the housing rearward of the forward side of the primary clutch dome.

8. The vehicle of claim **7**, wherein the air passage is configured to allow air to be pushed by the primary clutch assembly fan through the air passage into the secondary clutch chamber.

9. The vehicle of claim **1**, wherein the continuously variable transmission housing further comprises an air intake port disposed in the primary clutch dome.

10. An off-road utility vehicle, said vehicle comprising:

a prime mover structured and operable to provide motive force for the vehicle; and

a continuously variable transmission comprising:

a housing, wherein the housing comprises:

an inner cover;

an outer cover connectable to the inner cover to provide the housing having an interior chamber defined therein, the housing outer cover comprising:

a primary clutch dome formed entirely in the outer cover and defining a primary clutch chamber within the interior chamber of the housing;

a secondary clutch dome formed entirely in the outer cover and positioned rearward of the primary clutch dome and defining a secondary clutch chamber within the interior chamber of the housing; and

an air passage formed entirely in the outer cover and having a proximal end and a distal end, the air passage extending from the primary clutch dome at the proximal end and connecting to the secondary clutch dome at the distal end, the air passage structured and operable to direct air from the primary clutch chamber to the secondary clutch chamber;

an air intake port positioned forward of the proximal end of the air passage;

a primary clutch assembly at least partially disposed within the primary clutch dome; and

a secondary clutch assembly at least partially disposed within the secondary clutch dome.

11. The vehicle of claim **10**, wherein a fan of the primary clutch assembly is configured to draw air through the air intake port when the primary clutch assembly is rotating.

12. The vehicle of claim **10**, wherein the secondary clutch assembly includes a fan, and wherein the air passage is configured to allow air to be drawn from the primary clutch chamber into the secondary clutch chamber by the secondary clutch assembly fan when the secondary clutch assembly is rotating.

13. The vehicle of claim **10**, wherein the transmission housing includes an interstitial portion disposed between the primary clutch dome and the secondary clutch dome,

wherein the primary clutch dome, the secondary clutch dome, and the entire air passage protrude outward and away from the interstitial portion, and

wherein the air passage is positioned along a lower portion of the interstitial portion and extends from a lower half of the primary clutch dome at the proximal end and connects to a lower half of the secondary clutch dome at the distal end.

14. The vehicle of claim **13**, wherein the primary clutch dome protrudes outward and away from the interstitial portion a first distance and the secondary clutch dome protrudes outward and away from the interstitial portion a second distance, wherein the first distance is greater than the second distance, and wherein the proximal end of the air passage protrudes outward and away from interstitial portion a greater distance than the distal end of the air passage.

15. The vehicle of claim **13**, wherein the inner cover includes at least a portion of an exhaust air outlet disposed along an upper portion of the inner cover adjacent the secondary clutch dome.

16. The vehicle of claim **15**, wherein the housing includes a forward end and a rearward end, wherein the primary clutch dome includes a forward side disposed along the forward end of the housing and a rearward side connected to the interstitial portion, wherein the secondary clutch dome includes a forward side connected to the interstitial portion and a rearward side disposed along the rearward end of the housing, and wherein fresh air is only introduced to the housing forward of the rearward side of the primary clutch dome and exhaust air is only exhausted from the housing rearward of the forward side of the primary clutch dome.

17. The vehicle of claim **15**, wherein the air passage is configured to allow air to be pushed by the primary clutch assembly fan through the air passage into the secondary clutch chamber.

18. An off-road utility vehicle, said vehicle comprising:

a prime mover; and

a continuously variable transmission operably coupled to the prime mover, the continuously variable transmission comprising:

a housing, wherein the housing comprises:

an inner cover;

an outer cover connectable to the inner cover to provide the housing having an interior chamber defined therein, the housing outer cover comprising:

a primary clutch dome formed entirely in the outer cover and defining a primary clutch chamber within the interior chamber of the housing;

a secondary clutch dome formed entirely in the outer cover and defining a secondary clutch chamber within the interior chamber of the housing;

an interstitial portion disposed between the primary clutch dome and the secondary clutch dome; and

an air passage formed entirely in the outer cover and having a proximal end and a distal end, the air passage extending from a lower half of the primary clutch dome at the proximal end and connecting to a lower half of the secondary clutch dome at the distal end, the air passage structured to direct air from the primary clutch chamber to the secondary clutch chamber, wherein the primary clutch dome, the secondary clutch dome, and the entire air passage protrude outward and away from the interstitial portion, and

an air intake port in fluid communication with the primary clutch dome;

a primary clutch assembly at least partially disposed within the primary clutch dome; and

a secondary clutch assembly at least partially disposed within the secondary clutch dome, wherein the secondary clutch assembly includes a fan;

wherein the air passage is configured to allow air to be drawn from the primary clutch chamber into the secondary clutch chamber by the secondary clutch assembly fan when the secondary clutch assembly is rotating.

19. The vehicle of claim **18**, wherein the primary clutch dome protrudes outward and away from the interstitial portion a first distance and the secondary clutch dome protrudes outward and away from the interstitial portion a second distance, wherein the first distance is greater than the second distance.

20. The vehicle of claim **19**, wherein the proximal end of the air passage protrudes outward and away from the interstitial portion a greater distance than the distal end of the air passage.

21. The vehicle of claim **19**, wherein the inner cover includes at least a portion of an exhaust air outlet disposed along an upper portion of the inner cover adjacent the secondary clutch dome.

22. The vehicle of claim **21**, wherein the housing includes a forward end and a rearward end, wherein the primary clutch dome includes a forward side disposed along the forward end of the housing and a rearward side connected to the interstitial portion, wherein the secondary clutch dome includes a forward side connected to the interstitial portion and a rearward side disposed along the rearward end of the housing, and wherein fresh air is only introduced to the housing forward of the rearward side of the primary clutch dome and exhaust air is only exhausted from the housing rearward of the forward side of the primary clutch dome.

23. The vehicle of claim **18**, wherein the air intake port is disposed opposite a fan of the primary clutch assembly that is configured to draw air through the air intake port when the primary clutch assembly is rotating.

24. An air-cooled continuously variable transmission (CVT), said CVT comprising:

a primary clutch configured to mount to an output end of an engine crankshaft, the primary clutch comprises a stationary sheave and a moveable sheave, wherein the moveable sheave is configured to move towards the stationary sheave to engage a belt, resulting in rotation of the belt;

a first cooling fan coupled to the primary clutch;

a second cooling fan coupled with a secondary clutch; and

an outboard housing for enclosing the primary clutch and the secondary clutch, the outboard housing includes a primary clutch chamber configured to encase the primary clutch and a secondary clutch chamber configured to encase the secondary clutch, wherein the primary clutch chamber comprises an air duct configured to allow a cooling airstream to be drawn into the primary clutch chamber by the first cooling fan, wherein an air passage having a proximal end and distal end extends along a bottom of the outboard housing from the primary clutch chamber at the proximal end and connecting to the second clutch chamber at the distal end, wherein the air passage is configured to allow the cooling airstream to be pushed through the air passage into the secondary clutch chamber by the first cooling fan, wherein the second cooling fan is configured to cause the cooling airstream to be drawn onto the secondary clutch.

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