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(54) MULTIPLE AIRFOIL VANES

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F01D 9/00 (2006.01)

(52) **U.S. Cl.** **415/115**; 415/164; 415/165; 415/191; 415/186

(58) **Field of Classification Search** 415/115, 415/160, 163, 164, 166, 186, 191, 211.2, 415/165
See application file for complete search history.

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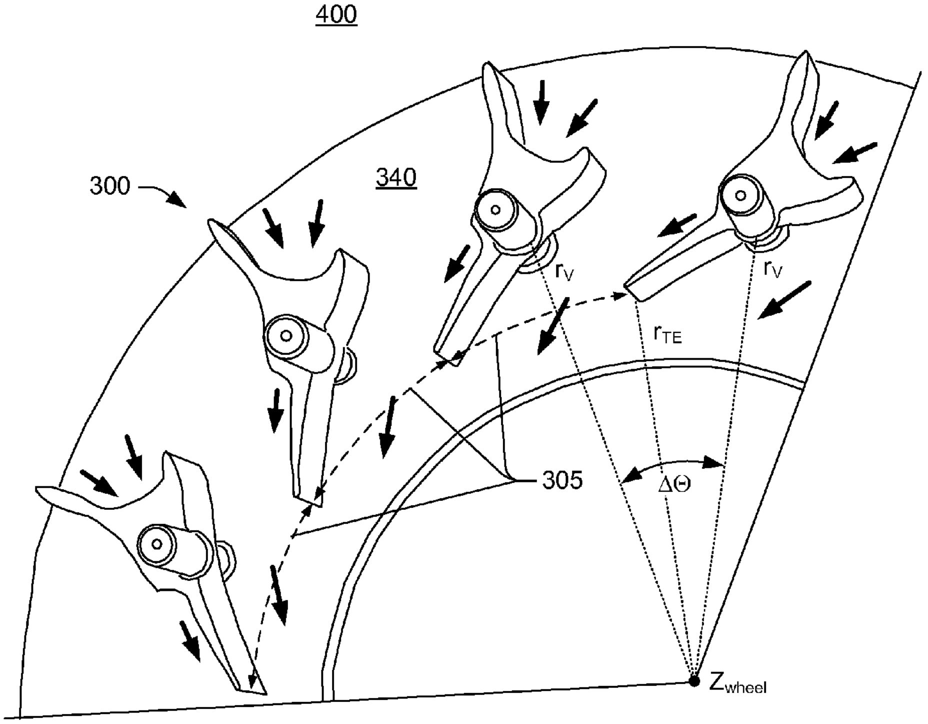
(57) **ABSTRACT**

A vane for a turbine assembly of a turbocharger includes a first airfoil that includes a length between a leading edge and a trailing edge, a second airfoil that includes a length between a leading edge and a trailing edge where the length of the first airfoil optionally differs from the length of the second airfoil, and one or more intra-vane throats defined at least in part by the first airfoil and the second airfoil. Various other examples of devices, assemblies, systems, methods, etc., are also disclosed.

23 Claims, 8 Drawing Sheets



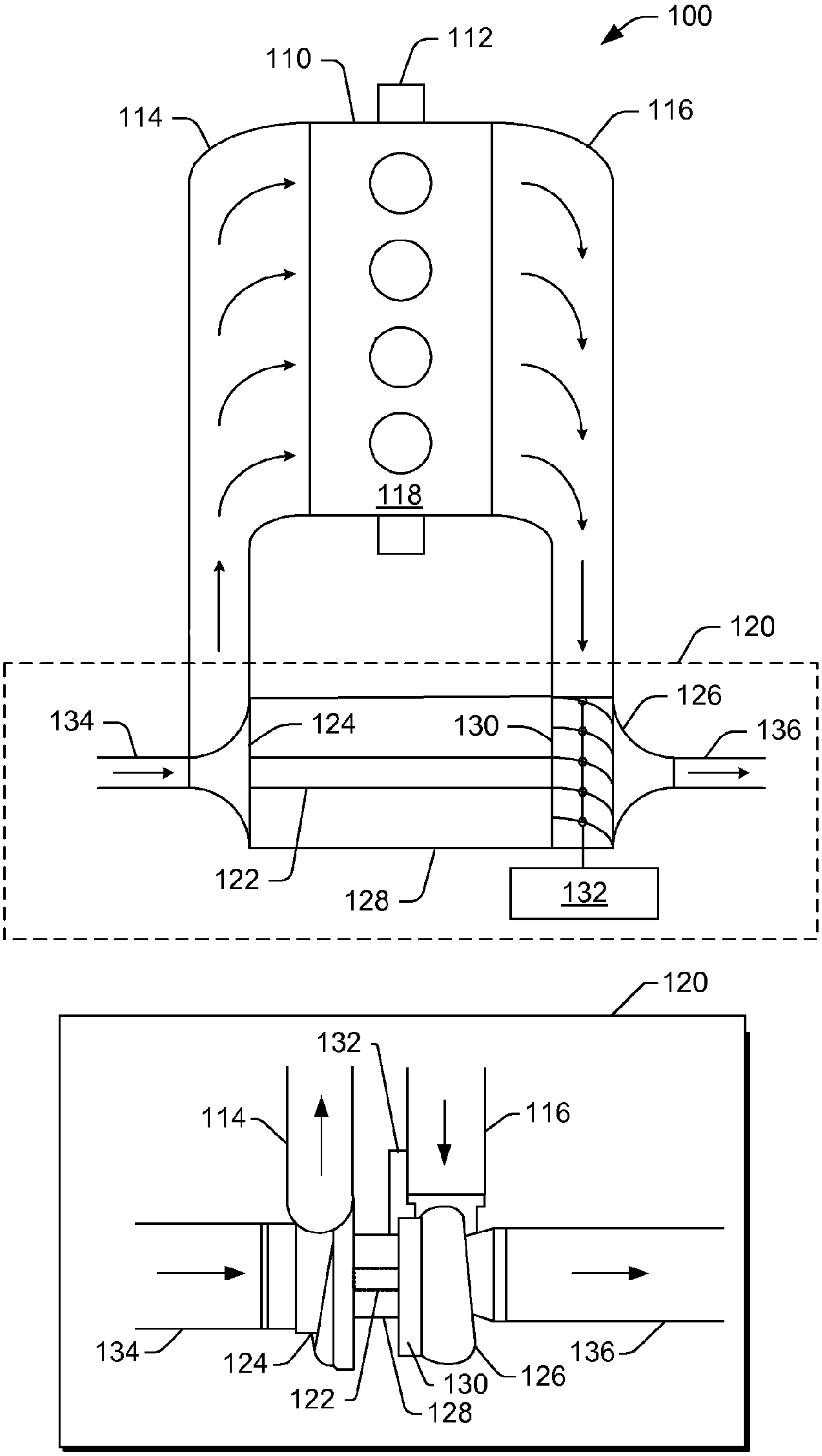

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Fig. 1

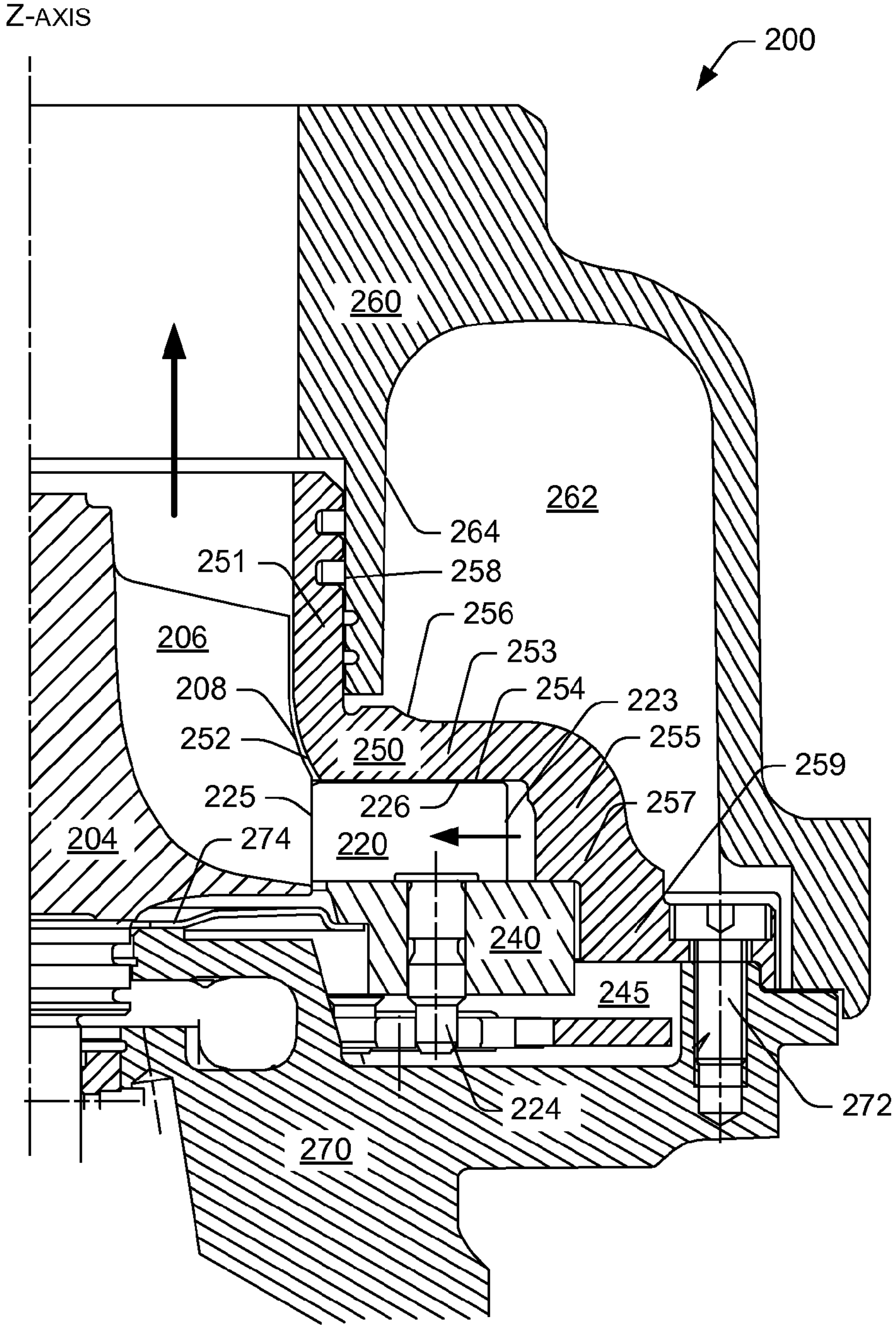
Z-AXIS
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Fig. 2

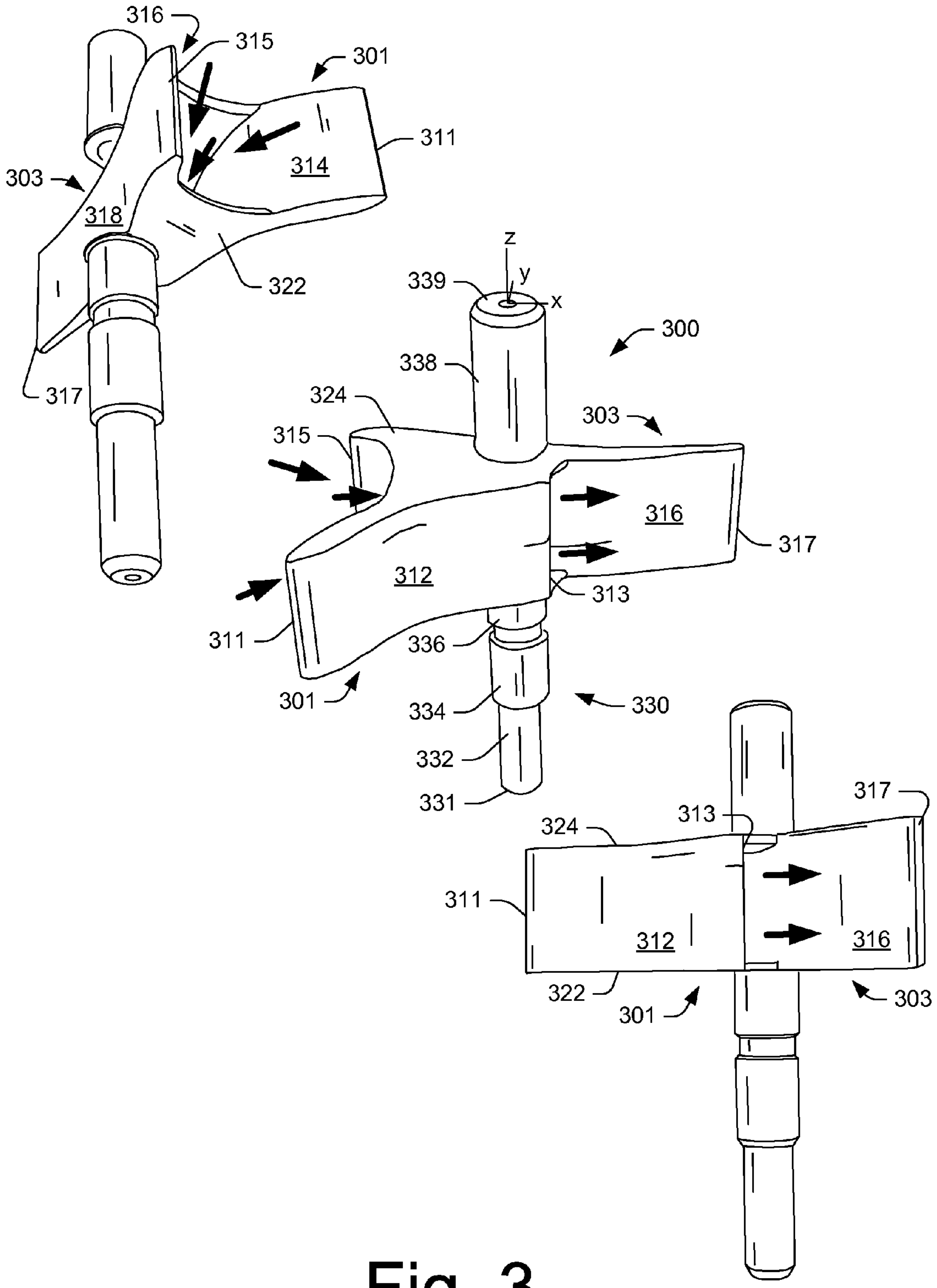
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Fig. 3

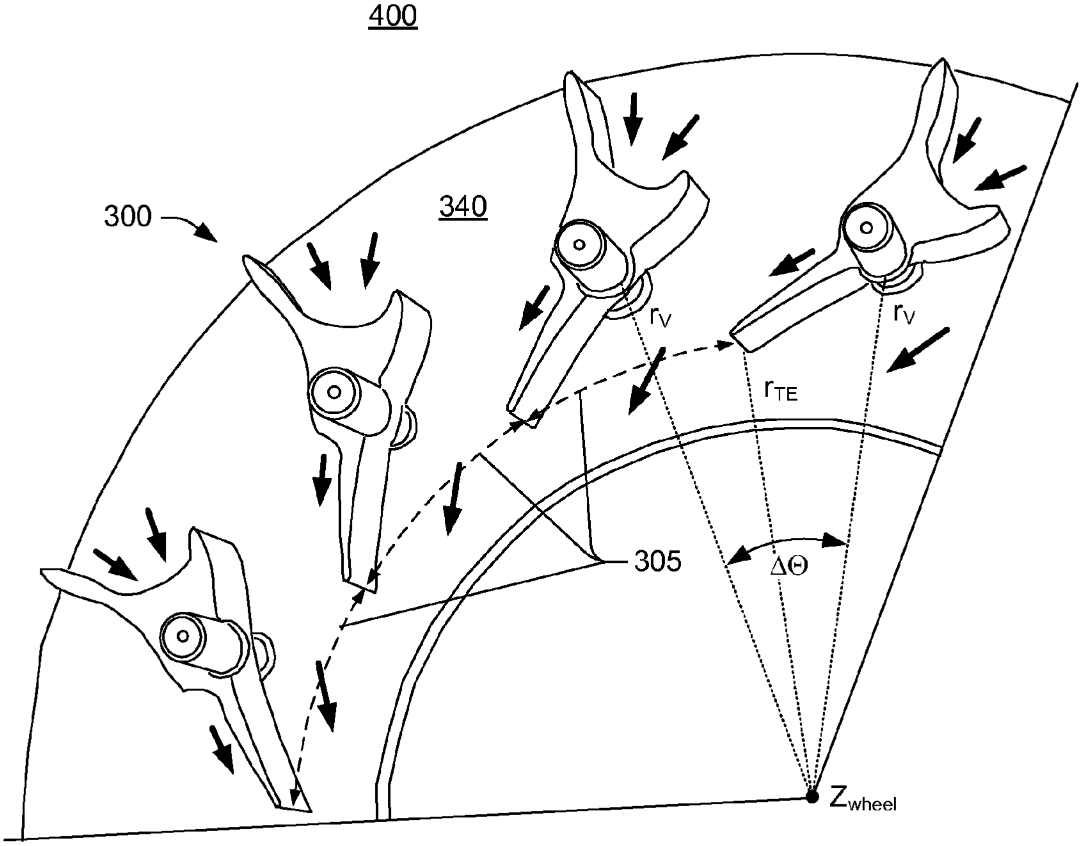
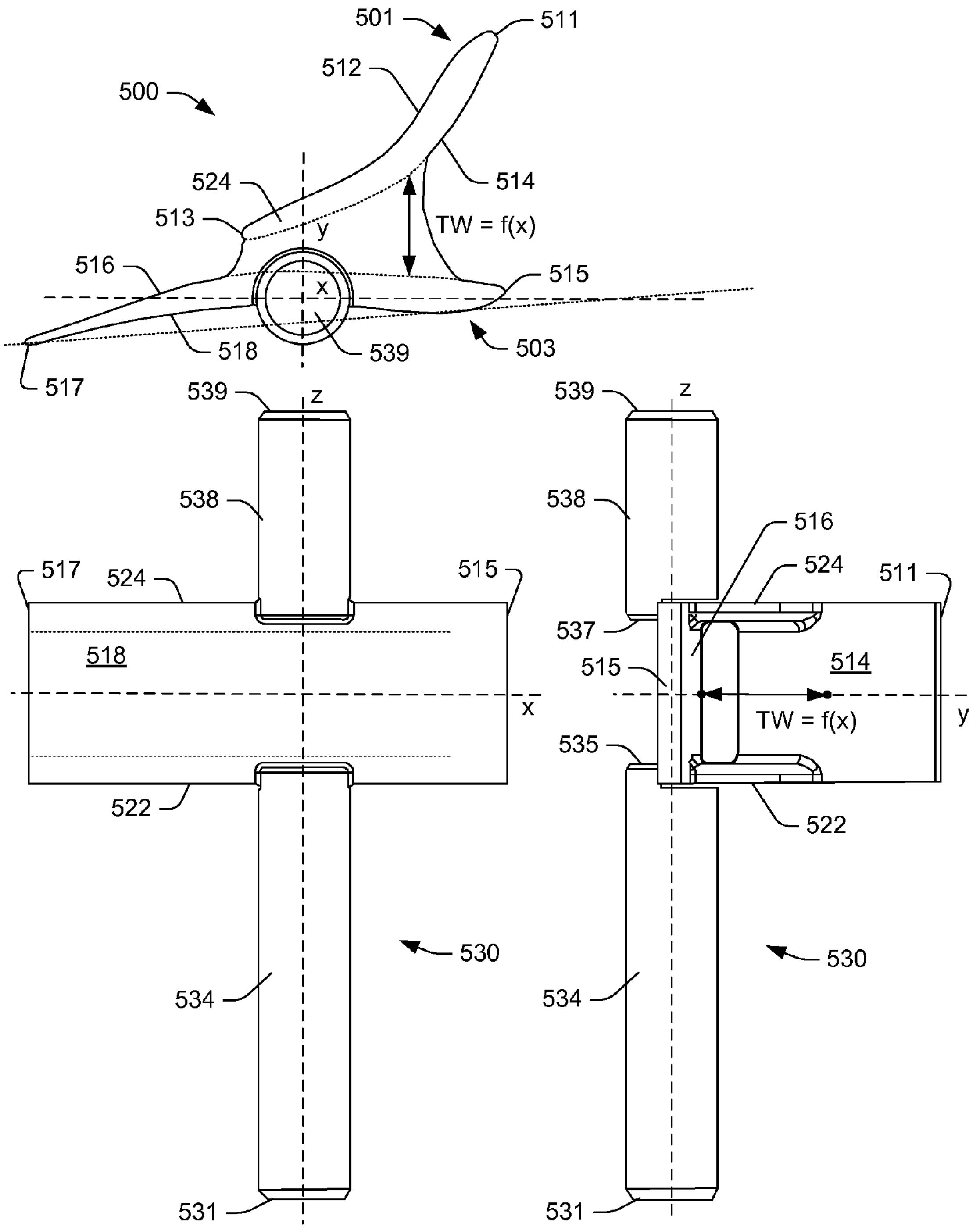


Fig. 4


501
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y
TW = f(x)
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522
530
534
531
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TW = f(x)
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522
530
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Fig. 5

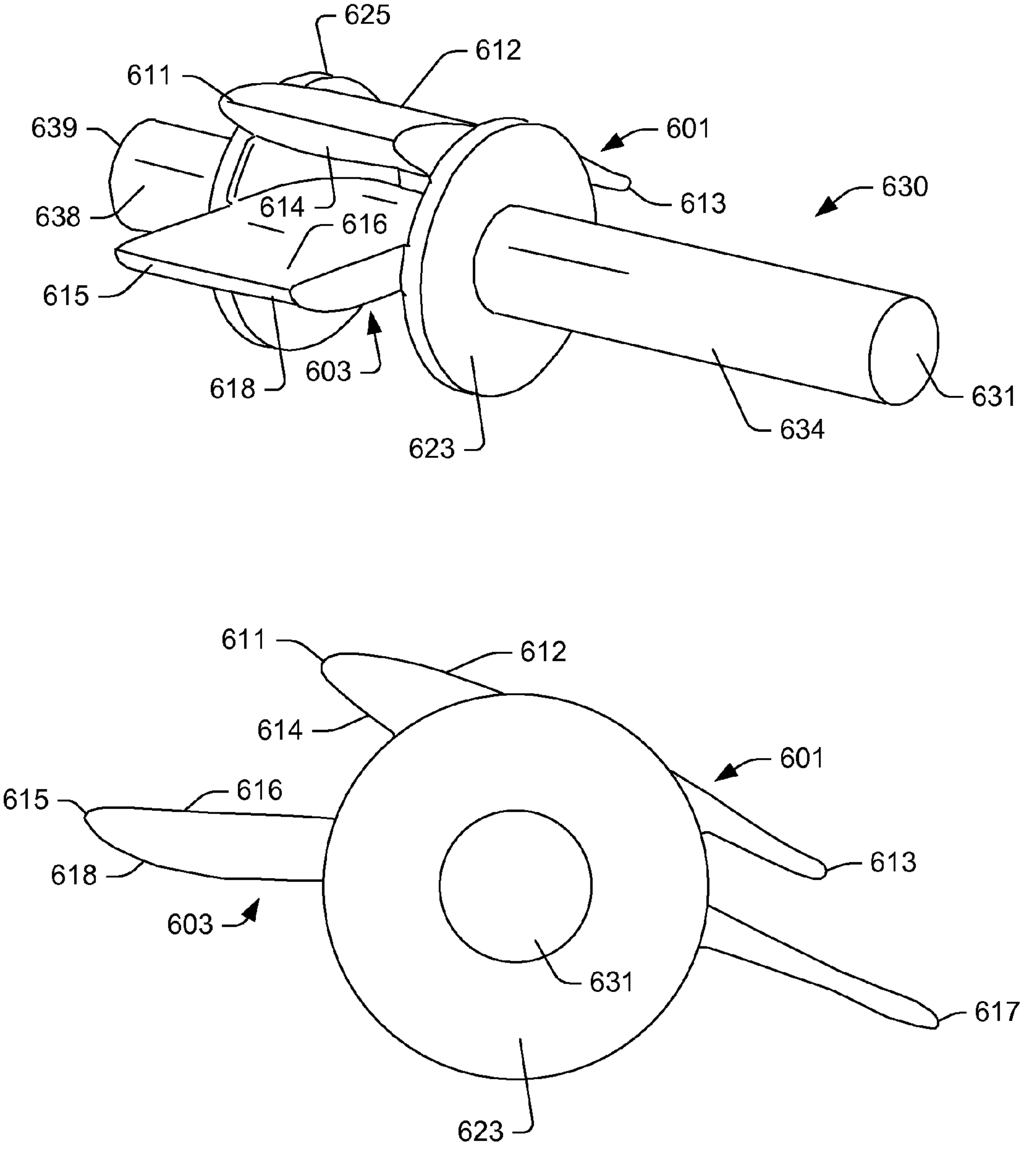
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Fig. 6

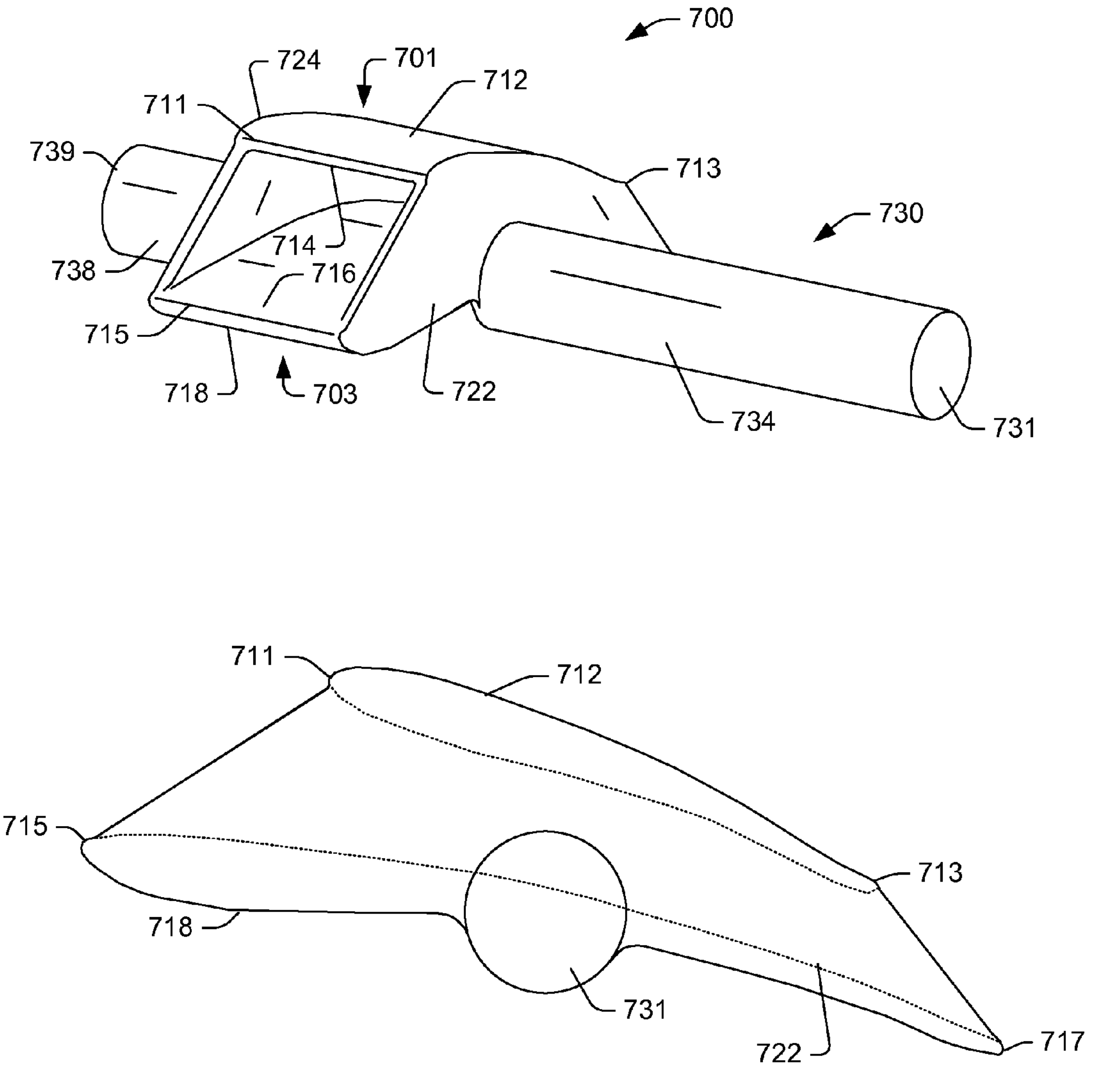
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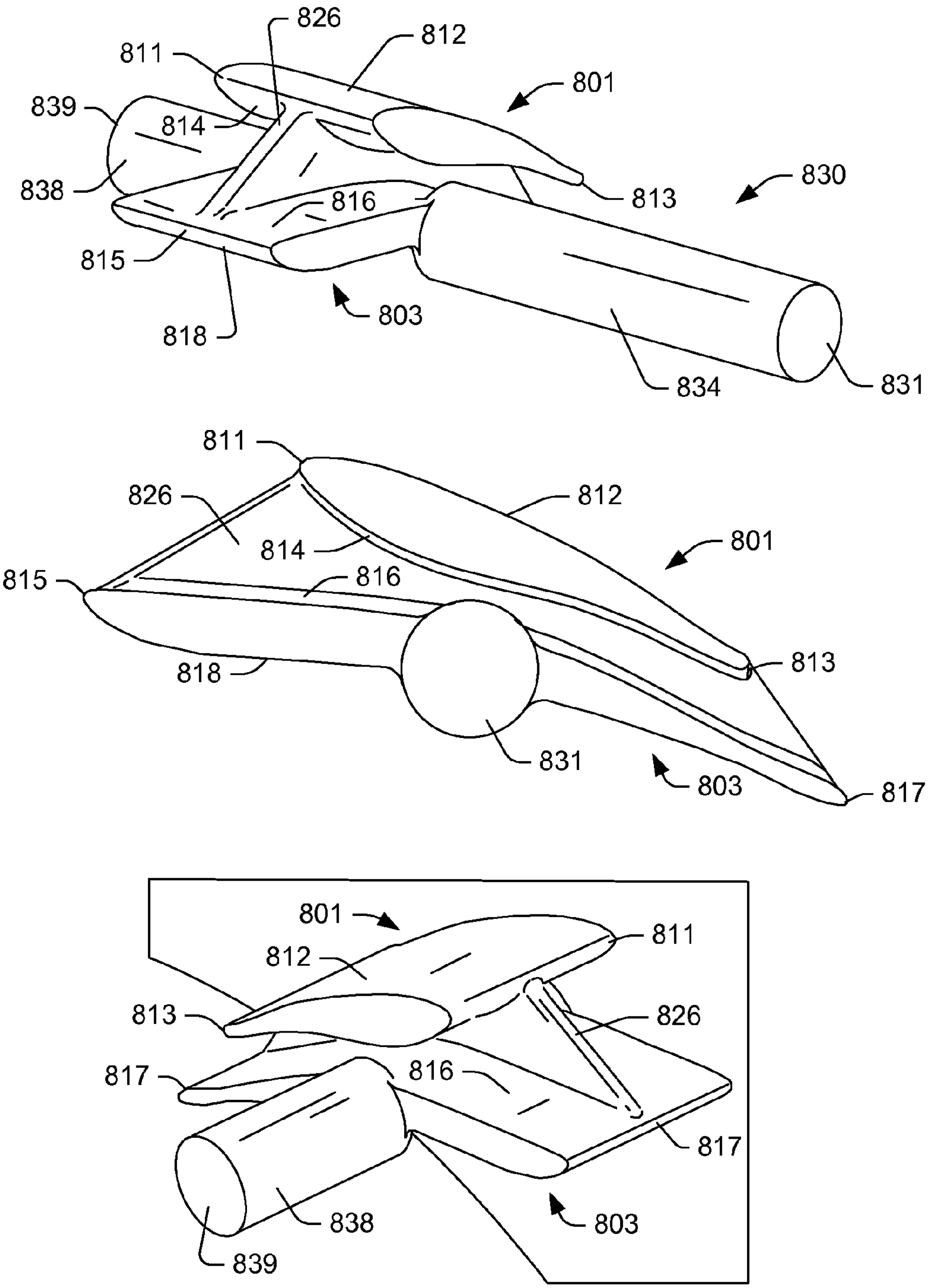
Fig. 7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816
817
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838
839

Fig. 8

MULTIPLE AIRFOIL VANES

TECHNICAL FIELD

Subject matter disclosed herein relates generally to turbomachinery for internal combustion engines and, in particular, vanes for directing exhaust to a turbine wheel.

BACKGROUND

Variable nozzle turbine assemblies act to accelerate exhaust exiting a volute (or volutes) and to direct exhaust more evenly to a turbine wheel. Wear and durability of a variable nozzle turbine assembly that relies on pivotable vanes depends heavily on vane design, especially design of a vane's airfoil. As exhaust flows through throats defined by adjacent vanes, the vanes experience torque. Further, torque typically varies with respect to vane position and exhaust condition. Airfoil design also affects wake and shock wave formation. Shock waves impact various components of a variable nozzle turbine assembly. Shock waves and wake generated by exhaust flowing past airfoils have a direct impact on turbine wheel performance and integrity.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the various methods, devices, assemblies, systems, arrangements, etc., described herein, and equivalents thereof, may be had by reference to the following detailed description when taken in conjunction with the accompanying drawings where:

FIG. **1** is a diagram of a turbocharger and an internal combustion engine;

FIG. **2** is a cross-sectional view of a turbine assembly that includes adjustable vanes to direct exhaust to a turbine wheel;

FIG. **3** is a series of perspective views of a vane with multiple airfoils;

FIG. **4** is a perspective view of a portion of a variable nozzle turbine assembly that includes a plurality of multiple airfoil vanes;

FIG. **5** is a series of views of a vane that includes multiple airfoils;

FIG. **6** is a series of views of a vane that includes multiple airfoils;

FIG. **7** is a series of views of a vane that includes multiple airfoils; and

FIG. **8** is a series of views of a vane that includes multiple airfoils with multiple intra-vane throats.

DETAILED DESCRIPTION

Vane design in a variable nozzle turbine relates to performance, wear and durability of a turbocharger. Vane airfoil characteristics determine, in part, torque generated about a vane's control axle as well as shock and wake created, which impacts turbine wheel performance and reliability. As to vane airfoil characteristics, certain characteristics benefit torque reduction and certain characteristics benefit wake reduction.

As described herein, in various examples, vanes are presented that have beneficial characteristics. In particular, various vanes presented herein include multiple airfoils. Such multiple airfoil vanes allow for interactions between airfoils, which enable smoother flows that can increase efficiency while minimizing shock/wake. For example, it is desirable to reduce vane trailing edge wake and shock intensity of rotor stator interaction thereby reducing unsteady turbine blade loading while meeting any required torque characteristics (e.g., no directional reversal and lower actuation force). Vanes with multiple and differently shaped airfoils also enable torque of a vane to be tuned.

Turbochargers are frequently utilized to increase output of an internal combustion engine. Referring to FIG. **1**, a conventional system **100** includes an internal combustion engine **110** and a turbocharger **120**. The internal combustion engine **110** includes an engine block **118** housing one or more combustion chambers that operatively drive a shaft **112**. As shown in FIG. **1**, an intake port **114** provides a flow path for air to the engine block **118** while an exhaust port **116** provides a flow path for exhaust from the engine block **118**.

The turbocharger **120** acts to extract energy from the exhaust and to provide energy to intake air, which may be combined with fuel to form combustion gas. As shown in FIG. **1**, the turbocharger **120** includes an air inlet **134**, a shaft **122**, a compressor **124**, a turbine **126**, a housing **128** and an exhaust outlet **136**. The housing **128** may be referred to as a center housing as it is disposed between the compressor **124** and the turbine **126**. The shaft **122** may be a shaft assembly that includes a variety of components.

Such a turbocharger may include one or more variable geometry units, which may use multiple adjustable vanes, an adjustable diffuser section, a wastegate or other features to control the flow of exhaust (e.g., Variable geometry turbine) or to control the flow of intake air (e.g., variable geometry compressor). In FIG. **1**, the turbocharger **120** further includes a variable geometry mechanism **130** and an actuator or controller **132**. The variable geometry mechanism **130** provides for adjusting or altering flow of exhaust to the turbine **126**.

Adjustable vanes positioned at an inlet to a turbine can operate to control flow of exhaust to the turbine. For example, GARRETT® VNT® turbochargers adjust the exhaust flow at the inlet of a turbine in order to optimize turbine power with the required load. Movement of vanes towards a closed position typically directs exhaust flow more tangentially to the turbine, which, in turn, imparts more energy to the turbine and, consequently, increases compressor boost. Conversely, movement of vanes towards an open position typically directs exhaust flow in more radially to the turbine, which, in turn, reduces energy to the turbine and, consequently, decreases compressor boost. Closing vanes also restrict the passage there through which creates an increased pressure differential across the turbine, which in turn imparts more energy on the turbine. Thus, at low engine speed and small exhaust gas flow, a VGT turbocharger may increase turbine power and boost pressure; whereas, at full engine speed/load and high gas flow, a VGT turbocharger may help avoid turbocharger overspeed and help maintain a suitable or a required boost pressure.

A variety of control schemes exist for controlling geometry, for example, an actuator tied to compressor pressure may control geometry and/or an engine management system may control geometry using a vacuum actuator. Overall, a VGT may allow for boost pressure regulation which may effectively optimize power output, fuel efficiency, emissions, response, wear, etc. Of course, a turbocharger may employ wastegate technology as an alternative or in addition to aforementioned variable geometry technologies.

FIG. **2** shows a cross-sectional view of a turbine assembly **200** having a turbine wheel **204** and vanes (see, e.g., the vane **220**) associated with a variable geometry mechanism. The turbine assembly **200** may be part of a turbocharger such as the turbocharger **120** of FIG. **1**. In the example of FIG. **2**, the turbine wheel **204** includes a plurality of blades (see, e.g., the blade **206**) that extend primarily in a radial direction outward from the z-axis. The blade **206**, which is representative of other blades, has an outer edge **208** where any point thereon can be defined in an r, Θ, z coordinate system (i.e., a cylindrical coordinate system). The outer edge **208** defines an exducer portion (where exhaust exits) and an inducer portion (where exhaust enters). The vane **220** directs exhaust to the inducer portion of the turbine wheel **204**.

In the example of FIG. **2**, the vane **220** is positioned on an axle or post **224**, which is set in a vane base **240**, which may be part of a variable geometry mechanism. As shown, the post **224** is aligned substantially parallel with the z-axis of the turbine wheel **204** and includes an upper surface **226**. While the post **224** is shown as not extending beyond the upper surface **226**, in other examples, a post may be flush with the upper surface **226** or extend above the upper surface **226** (e.g., received by a receptacle of the housing **250**, etc.).

With respect to adjustments, a variable geometry mechanism can provide for rotatable adjustment of the vane **220** along with other vanes to alter exhaust flow to the blades of the turbine wheel **204**. In general, an adjustment adjusts an entire vane and typically all of the vanes where adjustment of any vane also changes the shape of the flow space between adjacent vanes (e.g., vane throats or nozzles). In FIG. **2**, arrows indicate general direction of exhaust flow from an inlet end **223** to an outlet end **225** of the vane **220**. As mentioned above, adjustments toward "open" direct exhaust flow more radially to the turbine wheel **204**; whereas, adjustments toward "closed" direct exhaust flow more tangentially to the turbine wheel **204**.

The turbine assembly **200** is a particular example; noting that various vanes described herein may be implemented in other types of turbine assemblies. In the example of FIG. **2**, the assembly **200** has an insert **250** that includes, from the top down (i.e., along the z-axis): a substantially cylindrical or tubular portion **251**; a substantially planar, annular portion **253**; one or more extensions **255**; a leg or step portion **257**; and a base portion **259**. The base portion **259** extends to an opening configured for receipt of a bolt **272** to attach the insert **250** to a center housing **270**. As shown in FIG. **2**, a turbine housing **260** seats over the insert **250** and forms a volute **262**, defined at least in part by a volute side surface **264** of the housing **260** and a volute side surface **256** of the inset **250**. The volute **262** receives exhaust (e.g., from one or more cylinders of an engine) and directs the exhaust to the vanes.

During sharp operational transients, forces acting on a vane may affect operability or longevity. Such forces may be from flow of exhaust past surfaces of a vane, pressure differentials (e.g., between a command space **245** and vane space), or one or more other factors.

The controller **132** of FIG. **1** may be in communication with an engine control unit (ECU) that includes a processor and memory. The ECU may provide the controller **132** with any of a variety of information (e.g., instructions, throttle, engine speed, etc.) and the controller **132** may likewise provide the ECU with information (e.g., vane position, etc.). The controller **132** may be programmed by the ECU or by other techniques. The controller **132** may include a processor and memory, optionally as a single integrated circuit (e.g., a chip) or as more than one integrated circuit (e.g., a chipset).

As mentioned, various vanes presented herein include multiple airfoils that can enhance performance, particularly with respect to torque and wake. FIG. **3** shows an example of a vane **300** with multiple airfoils **301** and **303** along with a coordinate system (x, y, z). In the example of FIG. **3**, the airfoil **301** is shorter than the airfoil **303** (e.g., along the x-axis). The airfoil **301** has an outer facing airfoil surface **312** and an inner facing airfoil surface **314** where the surfaces **312** and **314** are disposed between a leading edge **311**, a trailing edge **313**, a base surface **322** and a hub surface **324**. The airfoil **303** has an inner facing airfoil surface **316** and an outer facing airfoil surface **318** where the surfaces **316** and **318** are disposed between a leading edge **315**, a trailing edge **317**, a base surface **322** and a hub surface **324**. Accordingly, in the example of FIG. **3**, the two airfoils **301** and **303** share a common base surface **322** and a common hub surface **324**. The airfoil surfaces **312**, **314**, **316** and **318** can be described with respect to the coordinate system and optionally with respect to projections, for example, in two of the three dimensions.

The vane **300** further includes a post **330** that extends axially downwardly (z-axis) from the base surface **322** to a base end **331** and axially upwardly from the hub surface **324** to a hub end **339**. The post **330** includes various cylindrical surfaces **332**, **334**, **336** and **338**, which may optionally be defined by a radius or radii about the z-axis. As mentioned, a vane may or may not have both an upwardly extending post portion and a downwardly extending post portion. Further, other mechanisms exist for adjusting a vane or vanes in a variable nozzle turbine assembly.

Arrows indicate approximate directions of exhaust flow through a throat defined by the airfoil **301** and **303**. As shown, exhaust enters the throat between the leading edges **311** and **315** and exits the throat between the trailing edge **313** of the airfoil **301** and a line or curve along the inner facing surface **316** of the airfoil **303** (e.g., consider a projection of the vane **300** in the x,z-plane).

In the example of FIG. **3**, the vane **300** includes a first airfoil **301** that includes a length between a leading edge **311** and a trailing edge **313**; a second airfoil **303** that includes a length between a leading edge **315** and a trailing edge **317** (e.g., where the length of the first airfoil may differ from the length of the second airfoil); and an intra-vane throat defined at least in part by the first airfoil **301** and the second airfoil **303**.

FIG. **4** shows an example of a portion **400** of a variable nozzle turbine assembly. The portion **400** includes four vanes such as the vane **300**. Trailing edges of a longer airfoil define a series of vane-to-vane throats **305**. Accordingly, in the example of FIG. **4**, the variable nozzle turbine assembly includes one intra-vane throat per vane and one inter-vane throat per vane (e.g., as defined between adjacent vanes). The portion **400** is shown with respect to a cylindrical coordinate system (r, Θ, Z) where the Z-axis is aligned with a rotational axis of a turbine wheel (Z_{wheel}). Each of the vanes **300** is set at a vane radius r_V and the vanes are separated at an angle ΔΘ. Upon adjustment of the vanes, a trailing edge radius r_{TE} of each vane **300** changes. Accordingly, each vane can be described with respect to a Cartesian coordinate system (x, y, z) and vanes in a variable nozzle turbine assembly can be further described with respect to a cylindrical coordinate system (r, Θ, Z).

As described herein, a variable nozzle turbine assembly can include a plurality of vanes that define inter-vane throats where each vane includes a first airfoil that includes a length between a leading edge and a trailing edge; a second airfoil that includes a length between a leading edge and a trailing edge (e.g., where the length of the first airfoil optionally differs from the length of the second airfoil); and one or more intra-vane throats defined at least in part by the first airfoil and the second airfoil. In such an assembly, the length of the second airfoil may exceed the length of the first airfoil and, accordingly, trailing edges of the second airfoil may define at least in part the inter-vane throats. In such an assembly, pivotable adjustment of the plurality of vanes alters shape of the inter-vane throats. As shown in the example of FIG. **4**, each vane includes an axle set in an annular ring.

As described herein, where multiple airfoil vanes enhance flow dynamics, a turbine wheel may be provided with characteristics that differ from a conventional turbine wheel (e.g., consider a conventional wheel designed to withstand shock). For example, a turbine wheel may be provided that has thinner blades, which can improve efficiency. In an example, an assembly includes a turbine wheel with blade thickness less than a conventional turbine wheel where the thinner blades are acceptable due to improved shock/wake of multiple airfoil vanes. As mentioned, thinner blades allow a turbine wheel to be more efficient than conventional variable nozzle turbine wheels (e.g., consider the blade **206** of FIG. **2** with a thickness less than that of a conventional wheel).

FIG. **5** shows an example of a vane **500** with multiple airfoils in a series of planar views (i.e., projections in a Cartesian coordinate x, y, z system). The vane **500** includes a post **530** that extends from a base end **531** to a hub end **539** with a lower portion **534** and an upper portion **538**. In a x,y-projection, the following features of the airfoils **501** and **503** are shown: leading edges **511** and **515**, trailing edges **513** and **517**, hub end surface **524** and post end **539**. In the x,y-projection, the intra-vane throat width (TW), as defined by the two airfoils **501** and **503** can be defined as a function of y with respect to x (e.g., TW=f(x)); noting that, in various examples, one or both inner airfoil surfaces **514** and **516** may vary with respect to z (e.g., TW=f(x, z)). In the other two projections, the airfoil surfaces **514**, **516** and **518** are shown. In the y,z-projection, the intra-vane throat outlet is shown as a substantially rectangular shape having an aspect ratio of about 4:1 (i.e., longer along the z-axis than the y-axis). The inlet of the intra-vane throat is defined between the leading edges **511** and **515** and has an aspect ratio of about 1:1.5 (i.e., longer along the y-axis that the z-axis). Accordingly, the throat narrows along its y-dimension from the leading edges **511** and **515** to the trailing edge **513**.

The y,z-projection also exhibits edges **535** of the lower post portion **534** and the upper post portion **538**, respectively, as well as a base end surface **522**. The position of the airfoils **501** and **503** with respect to the post portions **534** and **538** allows for essentially unimpeded flow along the outer facing surface **518** of the airfoil **503**. In the x,y-projection, a line drawn between a peak point near the leading edge **515** and the trailing edge **517** shows concavity of the airfoil surface **518**; noting that the outer facing airfoil surface of the airfoil **501** is also concave. Further, the inner facing airfoil surfaces **514** and **516** both have convexity in the x,y-projection. As described herein, an airfoil may have convexity, concavity or a combination of both in a z,y-projection (e.g., to shape the intra-vane throat exit, the intra-vane throat entrance or points therebetween).

In the example of FIG. **5**, the vane **500** includes a first airfoil **501** that includes a length between a leading edge **511** and a trailing edge **513**; a second airfoil **503** that includes a length between a leading edge **515** and a trailing edge **517** (e.g., where the length of the first airfoil may differ from the length of the second airfoil); and an intra-vane throat defined at least in part by the first airfoil **501** and the second airfoil **503**. As shown in FIG. **5**, the vane **500** includes a post with a post axis. As described herein, one of the airfoils may be offset from the post axis while the other airfoil may optionally be centered on the post axis.

FIG. **6** shows an example of a vane **600** with multiple airfoils **601** and **603**. In the example of FIG. **6**, the vane **600** has a post **630** with a lower portion **634** and an upper portion **638** disposed between a base end **631** and a hub end **639**. The vane **600** further includes a lower cylindrical plate **623** and an upper cylindrical plate **625**. The airfoils **601** and **603** may be selected and affixed to the plates **623** and **625**. Accordingly, generic post and supports may be provided for use with a variety of different airfoils. Alternatively, a vane may be cast as a single piece. In the example of FIG. **6**, the airfoil **601** has airfoil surfaces **612** and **614** disposed between a leading edge **611** and a trailing edge **613** and the airfoil **603** has airfoil surfaces **616** and **618** disposed between a leading edge **615** and a trailing edge **617**.

In the example of FIG. **6**, the vane **600** includes a first airfoil **601** that includes a length between a leading edge **611** and a trailing edge **613**; a second airfoil **603** that includes a length between a leading edge **615** and a trailing edge **617** (e.g., where the length of the first airfoil may differ from the length of the second airfoil); and an intra-vane throat defined at least in part by the first airfoil **601** and the second airfoil **603**.

FIG. **7** shows an example of a vane **700** with multiple airfoils **701** and **703**. In the example of FIG. **7**, the vane **700** has a post **730** with a lower portion **734** and an upper portion **738** disposed between a base end **731** and a hub end **739**. The vane **700** has a "box" shape formed in part by a lower **722** and an upper plate **724**. The vane **700** may be cast as a single piece or otherwise formed or assembled. In the example of FIG. **7**, the airfoil **701** has airfoil surfaces **712** and **714** disposed between a leading edge **711** and a trailing edge **713** and the airfoil **703** has airfoil surfaces **716** and **718** disposed between a leading edge **715** and a trailing edge **717**. Inner facing surfaces of the lower plate **722** and the upper plate **724** may optionally be shaped to enhance performance.

In the example of FIG. **7**, the vane **700** includes a first airfoil **701** that includes a length between a leading edge **711** and a trailing edge **713**; a second airfoil **703** that includes a length between a leading edge **715** and a trailing edge **717** (e.g., where the length of the first airfoil may differ from the length of the second airfoil); and an intra-vane throat defined at least in part by the first airfoil **701** and the second airfoil **703**.

FIG. **8** shows an example of a vane **800** with multiple airfoils **801** and **803**. In the example of FIG. **8**, the vane **800** has a post **830** with a lower portion **834** and an upper portion **838** disposed between a base end **831** and a hub end **839**. The vane **800** has a connector **826** that extends between the two airfoils **801** and **803**. The vane **800** may be cast as a single piece or otherwise formed or assembled. In the example of FIG. **8**, the airfoil **801** has airfoil surfaces **812** and **814** disposed between a leading edge **811** and a trailing edge **813** and the airfoil **803** has airfoil surfaces **816** and **818** disposed between a leading edge **815** and a trailing edge **817**. Surfaces of the connector **826** may optionally be shaped to enhance performance.

The vane **800** has two intra-vane throats, a hub side throat and a base side throat. While the intra-vane throats are shown as being essentially mirror images of each other, a vane with two airfoils and a connector may have throats that differ. For example, a lower throat may be shaped to enhance flow to a lower inducer portion of a turbine wheel while an upper throat may be shaped to enhance flow to an upper inducer portion of a turbine wheel. Further, while the example of FIG. **8** shows the connector **826** as being essentially planar and at a constant z position along the length of the vane **800**, such a connector may optionally be shaped differently (e.g., to provide certain characteristics).

In the example of FIG. **8**, the vane **800** includes a first airfoil **801** that includes a length between a leading edge **811** and a trailing edge **813**; a second airfoil **803** that includes a length between a leading edge **815** and a trailing edge **817** (e.g., where the length of the first airfoil may differ from the length of the second airfoil); and multiple intra-vane throats defined at least in part by the first airfoil **801** and the second airfoil **803**.

As described herein, one or more airfoils of a multiple airfoil vane may include a non-zero sweep angle, a non-zero lean angle, a non-zero twist angle or any combination thereof (e.g., to provide 3D variation of an airfoil along a z-axis). As described herein, one or more airfoils of a multiple airfoil vane may include 3D variations (e.g., length, width, etc.). As described herein, one or more airfoils of a multiple airfoil vane may include multiple anti-nodes along a camberline (e.g., consider an airfoil with three anti-nodes along a camberline).

As described herein, a method can include providing a plurality of multiple airfoil vanes where each vane includes at least one intra-vane throat and where adjacent vanes define inter-vane throats; and pivotably adjusting the plurality of vanes to alter only shape of the inter-vane throats. In such a method, closing the inter-vane throats by pivotably adjusting the plurality of vanes may effectively close the intra-vane throats. Such a method may further include providing a turbine wheel with improved efficiency, the improved efficiency resulting from turbine wheel blades configured for flow dynamics associated with the multiple airfoil vanes (e.g., where the vanes improve shock/wake characteristics of flow and allow for blades of lesser mass, thickness, etc.).

Although some examples of methods, devices, systems, arrangements, etc., have been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it will be understood that the example embodiments disclosed are not limiting, but are capable of numerous rearrangements, modifications and substitutions without departing from the spirit set forth and defined by the following claims.

What is claimed is:

1. A vane for a turbine assembly of a turbocharger, the vane comprising:
- a first airfoil that comprises a length between a leading edge and a trailing edge;
- a second airfoil that comprises a length between a leading edge and a trailing edge;
- one or more intra-vane throats defined at least in part by both the first airfoil and the second airfoil; and
- a post connected to the first airfoil and the second airfoil for pivoting the vane as a unit.

2. The vane of claim **1** wherein the vane comprises a single intra-vane throat.

3. The vane of claim**1** wherein the vane comprises two intra-vane throats.

4. The vane of claim **3** further comprising a connector that connects the first airfoil and the second airfoil and separates the two intra-vane throats.

5. The vane of claim **1** wherein the post comprises a post axis and wherein one of the airfoils comprises an offset from the post axis.

6. The vane of claim **5** wherein the other airfoil is centered on the post axis.

7. The vane of claim **1** wherein the length of the first airfoil differs from the length of the second airfoil.

8. The vane of claim **1** wherein the airfoils comprise convex inner airfoil surfaces.

9. The vane of claim **8** wherein the convex inner airfoil surfaces define, at least in part, the one or more throats.

10. The vane of claim **1** wherein the airfoils comprise concave outer airfoil surfaces.

11. The vane of claim **1** comprising a connector that connects the first airfoil to the second airfoil and fixes position of the first airfoil with respect to position of the second airfoil to thereby fixedly shape the one or more intra-vane throats.

12. A variable nozzle turbine assembly comprising:
- a plurality of vanes that define inter-vane throats wherein each vane comprises
  - a first airfoil that comprises a length between a leading edge and a trailing edge;
  - a second airfoil that comprises a length between a leading edge and a trailing edge;
  - one or more intra-vane throats defined at least in part by the first airfoil and the second airfoil; and
  - an axel connected to the first airfoil and the second airfoil for pivoting the vane as a unit.

13. The variable nozzle turbine assembly of claim **12** wherein the length of the second airfoil exceeds the length of the first airfoil and wherein the trailing edges of the second airfoils define at least in part the inter-vane throats.

14. The variable nozzle turbine assembly of claim **12** wherein pivotable adjustment of the plurality of vanes alters shape of the inter-vane throats.

15. The variable nozzle turbine assembly of claim **12** further comprising an annular ring that comprises openings configured for receipt of the axels.

16. The variable nozzle turbine assembly of claim **12** further comprising a turbine wheel, the turbine wheel configured with blades to match the flow dynamics of the plurality of vanes.

17. The variable nozzle turbine assembly of claim **12** comprising a connector that connects the first airfoil to the second airfoil and fixes position of the first airfoil with respect to position of the second airfoil to thereby fixedly shape the one or more intra-vane throats.

18. A method comprising:
- providing a plurality of multiple airfoil vanes wherein each vane comprises at least one intra-vane throat and wherein adjacent vanes define inter-vane throats; and
- pivotably adjusting the plurality of vanes to alter only shape of the inter-vane throats wherein the pivotably adjusting comprises rotating a post connected to the multiple airfoils of each of the vanes to pivot each vane as a unit.

19. The method of claim **18** further comprising closing the inter-vane throats by pivotably adjusting the plurality of vanes wherein the closing effectively closes the intra-vane throats.

20. The method of claim **18** further comprising providing a turbine wheel with improved efficiency, the improved efficiency resulting from blades configured for flow dynamics associated with the multiple airfoil vanes.

21. The method of claim **18** wherein each vane comprises a connector that connects its multiple airfoils and fixes positions of its multiple airfoils with respect to each other to thereby fixedly shape its at least one intra-vane throat.

22. A vane for a turbine assembly of a turbocharger, the vane comprising:
- a first airfoil that comprises a length between a leading edge and a trailing edge;
- a second airfoil that comprises a length between a leading edge and a trailing edge; and
- two intra-vane throats defined at least in part by both the first airfoil and the second airfoil.

23. The vane of claim **22** further comprising a connector that connects the first airfoil and the second airfoil and separates the two intra-vane throats.

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