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WARD et al.

(54) LIQUID-COOLED TURBINE HOUSING WITH INTERMEDIATE CHAMBER

(71) Applicant: BORGWARNER INC., Auburn Hills, MI (US)

(72) Inventors: Daniel N. WARD, Asheville, NC (US); Michael WALLS, Arden, NC (US)

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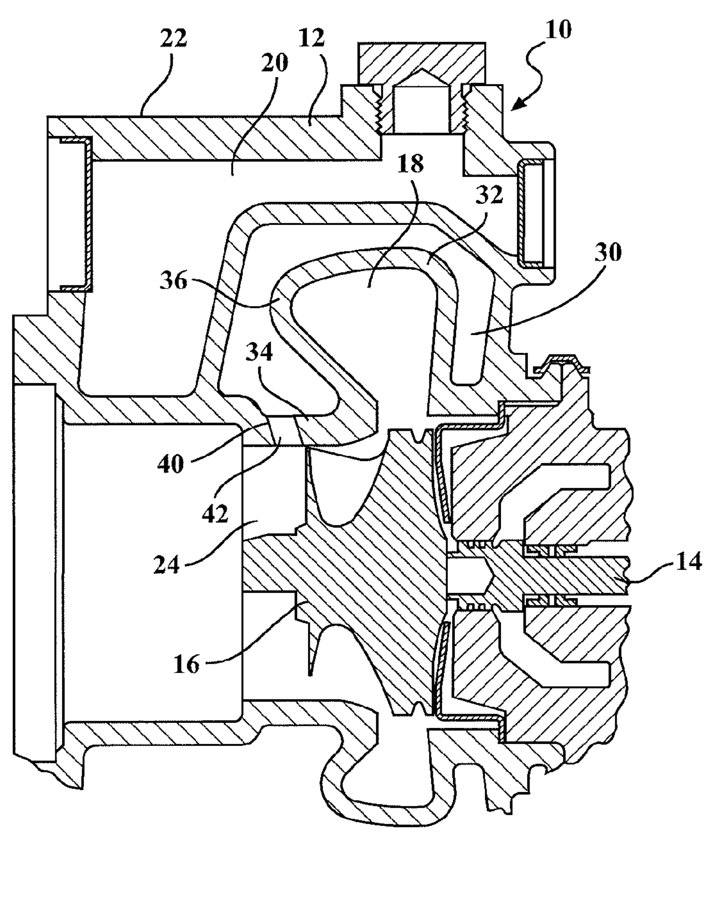
CPC ***F01D 25/14*** (2013.01); ***F01D 5/02*** (2013.01); ***F01D 25/24*** (2013.01); ***F01D 25/12*** (2013.01); ***F02B 37/00*** (2013.01); *F05D 2220/40* (2013.01); *F05D 2260/232* (2013.01)

(57) **ABSTRACT**

A turbocharger (**10**) with a liquid-cooled turbine housing (**12**) including an intermediate chamber (**30**) adjacent to the liquid chamber (**20**) of the turbine housing (**12**). The intermediate chamber (**30**) is between the liquid chamber (**20**) and a turbine housing exducer wall portion (**34**), partially near the turbine wheel blades. A preferred intermediate chamber (**30**) is a core that encloses the volute (**18**) and completely separates and insulates the hot volute (**18**) from the relatively cool liquid chamber (**20**). The intermediate chamber (**30**) may have a passage (**40**) as an exhaust gas inlet through the turbine housing exducer wall (**24**) or as an air inlet through the turbine housing (**12**) for flow into the intermediate chamber (**30**).



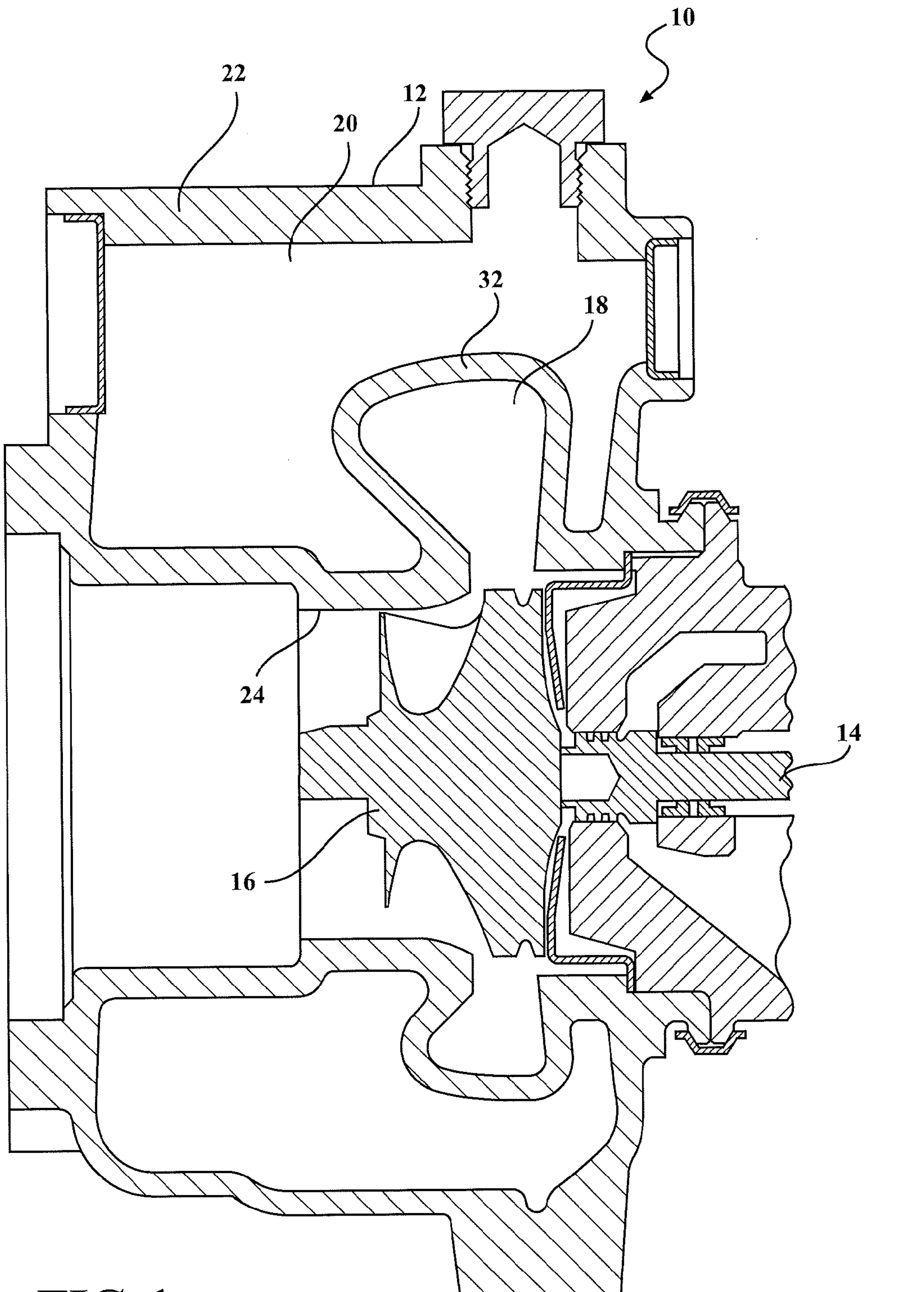


FIG. 1
PRIOR ART

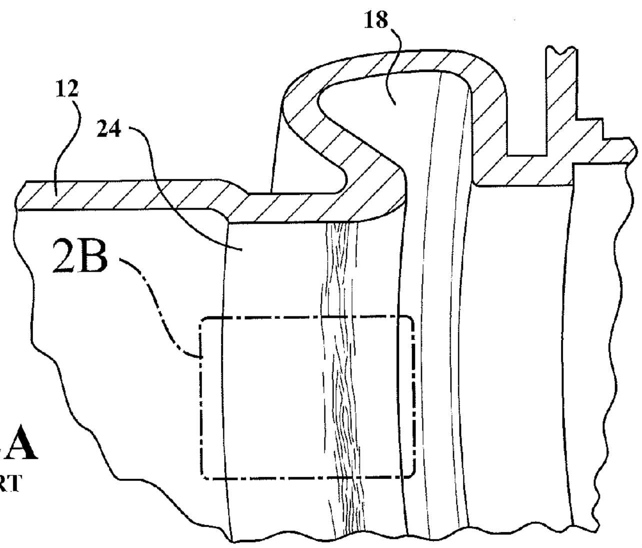


FIG. 2A
PRIOR ART

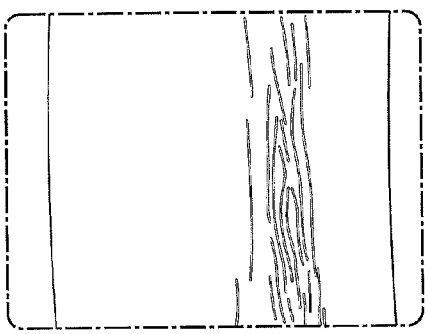


FIG. 2B
PRIOR ART

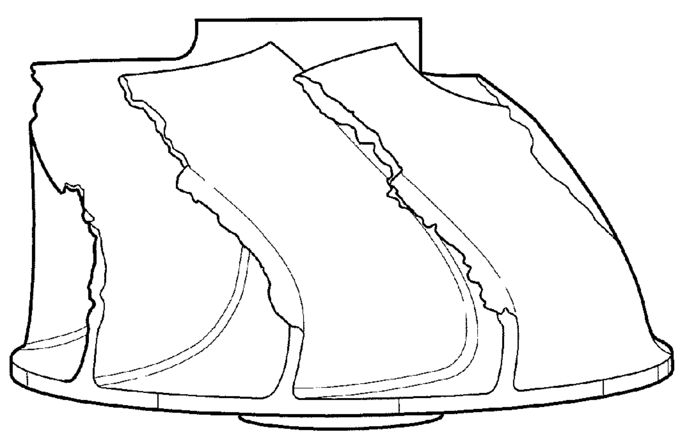


FIG. 2C
PRIOR ART

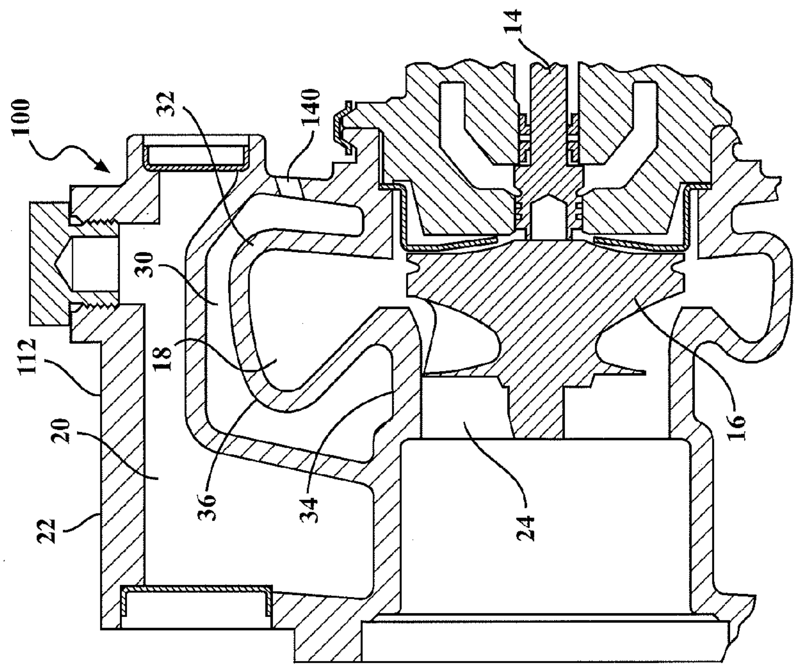

100
32
140
14
30
18
112
20
36
34
24
22
16

FIG. 4

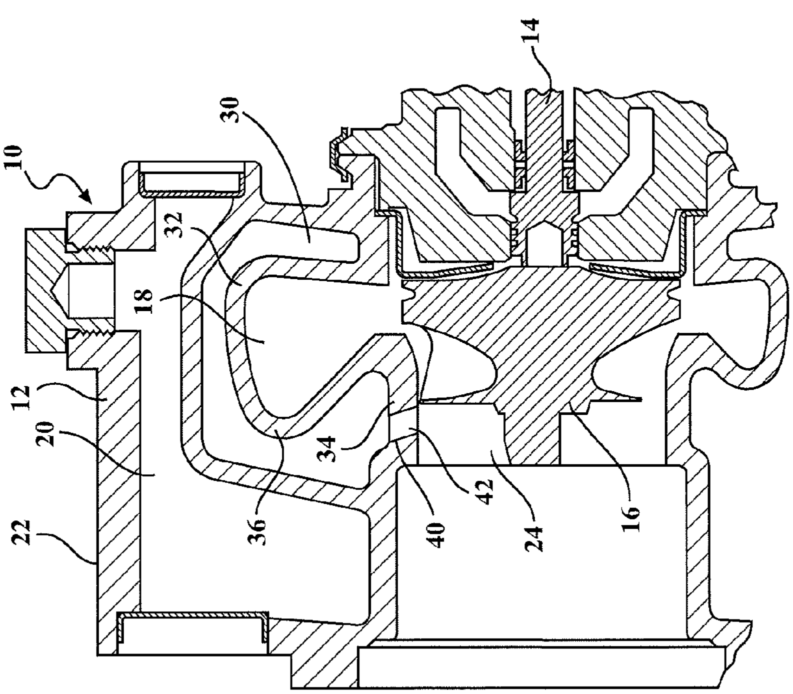

10
30
32
14
18
12
20
34
42
22
36
40
24
16

FIG. 3

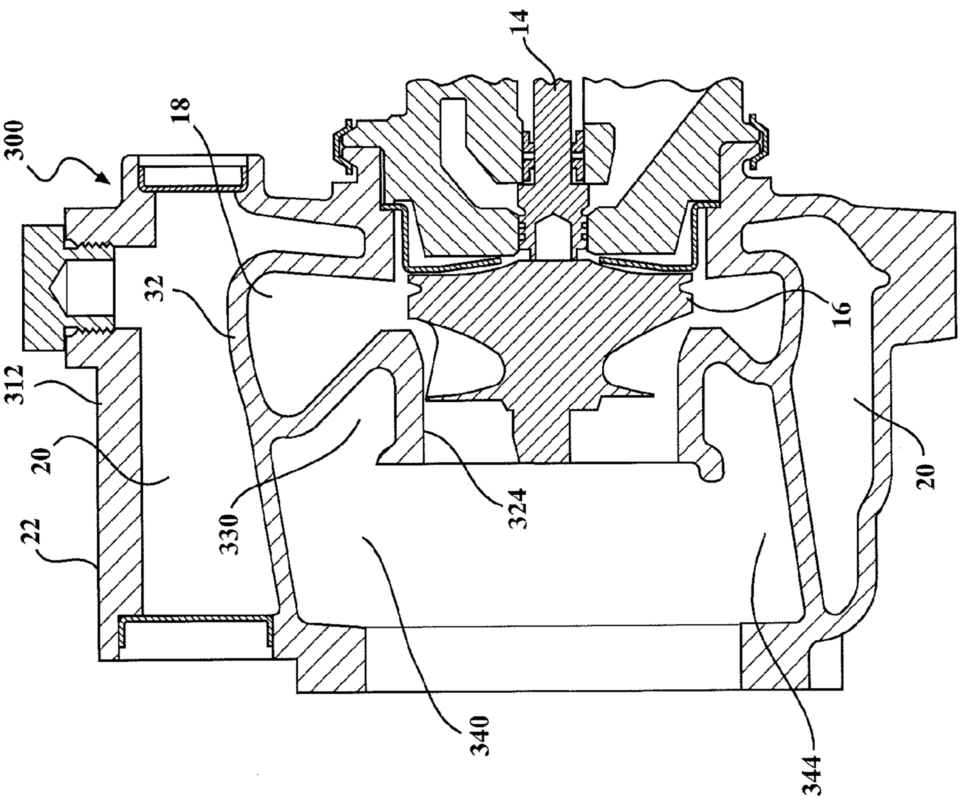

300
18
14
32
16
312
20
22
330
324
340
344
20

FIG. 6

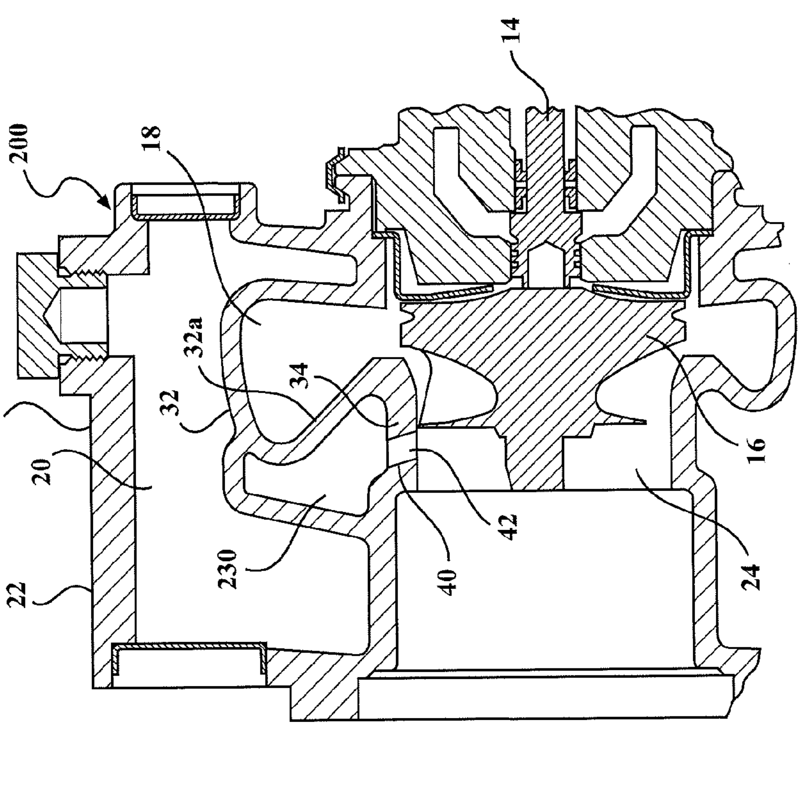

200
18
14
32a
34
32
212
20
16
22
230
40
42
24

FIG. 5

LIQUID-COOLED TURBINE HOUSING WITH INTERMEDIATE CHAMBER

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to and all the benefits of U.S. Provisional Application No. 61/903,431, filed on Nov. 13, 2013, and entitled "Liquid-Cooled Turbine Housing with Intermediate Chamber," which is incorporated herein by reference.

BACKGROUND

[0002] 1. Field of the Disclosure

[0003] This disclosure relates to liquid-cooled turbine housings for turbochargers. More particularly, this disclosure relates to an intermediate chamber adjacent to a liquid cooling chamber of the turbine housing.

[0004] 2. Description of Related Art

[0005] Advantages of turbocharging include increased power output, lower fuel consumption, reduced pollutant emissions, and improved transient response. The turbocharging of engines is no longer primarily seen from a high-power performance perspective, but is rather viewed as a means of reducing fuel consumption and environmental pollution on account of lower carbon dioxide (CO_2) emissions. Currently, a primary reason for turbocharging is using exhaust gas energy to reduce fuel consumption and emissions. In turbocharged engines, combustion air is pre-compressed before being supplied to the engine. The engine aspirates the same volume of air-fuel mixture as a naturally aspirated engine, but due to the higher pressure, thus higher density, more air and fuel mass is supplied into a combustion chamber in a controlled manner. Consequently, more fuel can be burned, so that the engine's power output increases relative to the speed and swept volume.

[0006] In exhaust gas turbocharging, some of the exhaust gas energy, which would normally be wasted, is used to drive a turbine. The turbine includes a turbine wheel that is mounted on a shaft and is rotatably driven by exhaust gas flow. The turbocharger returns some of this normally wasted exhaust gas energy back into the engine, contributing to the engine's efficiency and saving fuel. A compressor, which is driven by the turbine, draws in filtered ambient air, compresses it, and then supplies it to the engine. The compressor includes a compressor wheel that is mounted on the same shaft so that rotation of the turbine wheel causes rotation of the compressor wheel.

[0007] Turbochargers typically include a turbine housing connected to the engine's exhaust manifold, a compressor housing connected to the engine's intake manifold, and often a center housing coupling the turbine and compressor housings together. The turbine housing defines a volute that surrounds the turbine wheel and that receives exhaust gas from the engine. The turbine wheel in the turbine housing is rotatably driven by a controlled inflow of exhaust gas supplied from the exhaust manifold.

[0008] Referring to FIG. **1**, as an example, water-cooled turbine housings of turbochargers are known where water enters a liquid cooling chamber of the turbine housing to keep the outer shell cool, given that the engine exhaust flowing through the volute is extremely hot. In some configurations, for example, the exhaust gas is about 700 degrees Celsius. The inner walls enclosing the exhaust area need to expand due to the thermal growth from the surrounding high temperatures, but they are constrained from outward expansion by the cooler outer shell structure. Thus, the inner walls must expand internally (e.g., inward) to accommodate the high exhaust temperatures.

[0009] Typically, tight clearances are required between the turbine housing and turbine wheel. There is risk that the expanding internal walls in the exducer region of the turbine housing will interfere with, such as rub, the turbine wheel that spins at high speeds. Significant damage to the turbine housing and turbine wheel can result. FIG. **2**A shows regions of potential interference (rubbing) on the turbine housing exducer region adjacent to the blades of the turbine wheel. FIG. **2**B shows how rub markings may appear within the exducer profile surface of the turbine housing after a turbine wheel rubbed the surface. Similarly, FIG. **2**C shows typical rub damage on a turbine wheel that has rubbed on the inner surface of the turbine housing. Once the turbine wheel and turbine housing interfere, the problem can quickly escalate into broken turbine wheel blades or even separation of the turbine wheel from the shaft. Thus, concerns may arise with a turbine wheel interfering with the turbine housing exducer wall of a liquid-cooled turbine housing.

[0010] Also, a liquid-cooled turbine housing may reduce thermal efficiency. Relatively cool liquid directly contacting the hot inner volute wall can reduce thermal efficiency due to exhaust gas heat energy dissipating into the liquid.

SUMMARY

[0011] This disclosure relates to turbochargers with liquid-cooled turbine housings with an intermediate chamber, such as an additional exhaust chamber, adjacent to the liquid chamber of the turbine housing. Such an intermediate chamber insulates the hot volute from the relatively cool liquid chamber.

[0012] Thus, the turbine housing with an intermediate chamber adjacent to the liquid chamber can address concerns with thermal strains induced within the turbine housing, which can cause the exducer region to constrict instead of expand with high exhaust temperatures and any resulting failures from a turbine wheel contacting the turbine housing exducer wall.

[0013] Also, the liquid-cooled turbine housing with an intermediate chamber adjacent to the liquid chamber may improve efficiency of the turbine stage by keeping the exhaust gas heat energy from dissipating into the liquid in the liquid chamber. Relatively cool liquid in the liquid chamber does not contact all or part of the hot inner volute wall so thermal efficiency is not lost with exhaust gas heat energy dissipating into the liquid.

[0014] In summary, the benefits of a turbine housing with an intermediate chamber between the liquid chamber and the exducer region of the turbine housing include reduced thermal strains and improved thermal efficiency.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Advantages of the present disclosure will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0016] FIG. **1** is a cross-sectional view of a prior art turbine side of a turbocharger with a liquid-cooled turbine housing;

[0017] FIG. **2**A is an example of a cross-section of a prior art liquid-cooled turbine housing showing damage to the exducer profile surface after a turbine wheel rubbed the surface;

[0018] FIG. **2**B is an enlarged portion of the turbine housing of FIG. **2**A;

[0019] FIG. **2**C is an example of typical damage to a turbine wheel that has rubbed on the inner surface of the turbine housing;

[0020] FIG. **3** is a cross-sectional view of a liquid-cooled turbine housing including an intermediate chamber adjacent to the liquid chamber that totally encloses the volute wall with an optional passage that allows exhaust gas into the intermediate chamber;

[0021] FIG. **4** is a cross-sectional view of an alternative embodiment liquid-cooled turbine housing including an intermediate chamber adjacent to the liquid chamber that totally encloses the volute core wall with an optional passage allowing air into the intermediate chamber;

[0022] FIG. **5** is a cross-sectional view of another alternative embodiment liquid-cooled turbine housing with an intermediate chamber that partially encloses the volute; and

[0023] FIG. **6** is a cross-sectional view of another alternative embodiment liquid-cooled turbine housing with an intermediate chamber that partially encloses the volute with a simple casting.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0024] Referring to FIG. **3**, a turbocharger **10** includes a compressor wheel (not shown) in a compressor housing (not shown) that is rotatably driven via a rotatable shaft **14** by a turbine wheel **16** in a turbine housing **12**. The turbine housing **12** is a liquid-cooled turbine housing **12**, and includes an exhaust gas inlet (not shown) configured to be connected to an exhaust manifold of an engine. The turbine housing **12** includes an exhaust gas outlet (e.g., an exducer) **24**, and a volute **18**. The volute **18** defines a main chamber that surrounds the turbine wheel **16**, and directs hot exhaust gas toward blades of the turbine wheel **16**. The turbine housing **12** further includes an outer shell **22**. A liquid chamber **20**, for example a water core, is defined between the outer shell **22** and an inner wall **36** that includes a wall portion **32** forming the volute **18** and a wall portion **34** forming the exducer **24**. Thus, the liquid chamber **20** is adjacent to an outer shell **22** of the turbine housing **12**.

[0025] The turbocharger **10** with a liquid-cooled turbine housing **12** has an intermediate chamber **30** disposed between the liquid chamber **20** and the inner wall **36**, including the exducer wall portion **34** and the volute wall portion **32**. The turbine housing exducer region is preferably completely adjacent to the intermediate chamber **30** to help control thermal expansion of the exducer wall portion **34** and to minimize thermal strains within the turbine housing **12**. The intermediate chamber **30** totally encloses the volute **18**. The intermediate chamber **30** completely separates and insulates the entire hot volute **18** (with hot exhaust gas) from the relatively cool liquid chamber **20**, which can improve efficiency of the turbine stage by keeping the exhaust gas heat energy from dissipating into the liquid in the liquid chamber **20**. Relatively cool liquid of the liquid chamber **20** does not contact the volute wall portion **32** so thermal efficiency is not lost with exhaust gas heat energy dissipating into the liquid. This improves turbine efficiency as turbine exhaust gases remain at the highest possible temperature before entering the turbine wheel **16**.

[0026] The intermediate chamber **30** as in FIG. **3** may optionally have a passage **40** through the exducer wall portion **34** that allows exhaust gas into the intermediate chamber **30**. The exhaust gas passage **40** may be a slot **42** through the exducer wall portion **34**, or alternatively may extend around circumference of the exducer wall portion **34** to permit flow of exhaust gas into the intermediate chamber **30**. The slot **42**, whether partially or fully around the exducer wall portion **34** may reduce stiffness of the volute wall portion **32** and may increase the temperature in the intermediate chamber **30**. The volute wall portion **32** can then expand and contract as necessary, and the thermal stresses are reduced in the exducer wall portion **34** directly enclosing the turbine wheel **16**. This configuration therefore minimizes the inward thermal growth of the turbine housing exducer wall portion **34**.

[0027] Referring to FIG. **4**, an alternative turbocharger **100** is similar the turbocharger **10** described above with respect to FIG. **3**, and like reference numbers are used to refer to like parts. The turbocharger **100** includes a liquid-cooled turbine housing **112** with an intermediate chamber **30** adjacent to the liquid chamber **20**. The intermediate chamber **30** is disposed between the liquid chamber **20** and the inner wall **36**, including the exducer wall portion **34** and the volute wall portion **32**, and totally encloses the volute **18**. The turbocharger **100** includes a passage **140** through the outer wall of the turbine housing **112**, allowing air into the intermediate chamber **30**. The passage **140** passing through the turbine housing **112** serves as an air inlet and allows flow of ambient air as the intermediate gas in the intermediate chamber **30** between the liquid chamber **20** and volute **18**.

[0028] Referring to FIG. **5**, another alternative turbocharger **200** is similar the turbocharger **10** described above with respect to FIG. **3**, and like reference numbers are used to refer to like parts. The turbocharger **200** includes a liquid-cooled turbine housing **212** with an intermediate chamber **230** adjacent to the liquid chamber **20**. The intermediate chamber **230** partially encloses the volute **18** and is disposed between the liquid chamber **20** and the exducer wall portion **34** and at least a portion **32***a* of the volute wall portion **32**. The intermediate chamber **230** insulates a portion of volute **18** from the liquid chamber **20**, but the intermediate chamber **230** only partially encloses the volute wall portion **32**.

[0029] The configuration of FIG. **5** may be easier to manufacture than some of the previously described embodiments due to the reduced complexity of the core design, however, this configuration will not be as thermally efficient given that some of the cool liquid is directly contacting the volute wall portion **32**. While a sand core could be kept intact in a closed intermediate core of the intermediate chamber **230**, it may be desirable to machine a slot or passage **40** either partially or fully around the exducer wall portion **34** downstream of the position of the turbine wheel **16** to reduce the stiffness of the volute wall portion **32** and to increase the temperature in the intermediate chamber **230**. This configuration is primarily concerned with ensuring that the turbine wheel **16** does not interfere with the turbine housing's exducer wall portion **34**, while being less concerned with the reduced thermal efficiency.

[0030] Referring to FIG. **6**, another alternative turbocharger **300** is similar the turbocharger **10** described above with respect to FIG. **3**, and like reference numbers are used to refer to like parts. The turbocharger **300** includes a liquid-cooled turbine housing **312** with an intermediate chamber **330** that partially encloses the volute **18** with a less complex casting. This allows for easier sand shake-out after parts are cast. This intermediate chamber **330** may be integrated into an exhaust core with a substantially open passage **340**. The intermediate chamber **330** largely open to the exhaust core still creates the expandable annular exducer wall portion **334**. An optional circumferential passage **344** extends fully around the exducer wall portion **334**. The circumferential passage **344** is disposed downstream of the turbine wheel **16** and allows exhaust gas into the intermediate chamber **330**. The circumferential passage **344** may increase the temperature in the intermediate chamber **30**.

[0031] The formation of cores in castings and cost of casting may also dictate the embodiment as well as benefits of reduced thermal strains and improved thermal efficiency. For more complex cores, the intermediate sand core could be kept intact within the casting or a thin-shell ceramic or other insert could be used in the mold during the pour. In all disclosed castings, the intermediate chamber **30** separates the exducer wall portion **34** from the liquid chamber **20**.

[0032] The invention is described in an illustrative manner, and it is to be understood that the terminology used is intended to be in the nature of words of description rather than limitation. Many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced other than as specifically enumerated in the description.

What is claimed is:

1. A liquid-cooled turbine housing (**12**) configured to cool a turbine section of a turbocharger (**10**), the turbine housing (**12**) comprising

a liquid chamber (**20**) adjacent to an outer shell (**22**),

an intermediate chamber (**30**) between the liquid chamber (**20**) and a turbine housing exducer wall portion (**34**).

2. The turbine housing (**12**) of claim **1** wherein the intermediate chamber (**30**) has an exhaust gas passage (**40**) through the turbine housing exducer wall portion (**34**).

3. The turbine housing (**12**) of claim **1** wherein an exhaust gas passage (**40**) extends fully around the circumference of the turbine housing exducer wall portion (**34**).

4. The turbine housing (**12**) of claim **1** wherein the intermediate chamber (**30**) has an air-inlet passage (**40**) through the turbine housing (**12**) configured to provide a flow of air into the intermediate chamber (**30**).

5. The turbine housing (**12**) of claim **1** wherein the intermediate chamber (**30**) encloses a turbine volute wall portion (**32**).

6. A turbocharger (**10**) comprising:

a turbine wheel (**16**) on a rotatable shaft (**14**); and

a liquid-cooled turbine housing (**12**), the turbine housing (**12**) including

a volute (**18**) surrounding the turbine wheel (**16**);

a liquid chamber (**20**) adjacent to an outer shell (**22**) of the turbine housing (**12**);

an exducer wall portion (**34**) adjacent to a portion of the turbine wheel (**16**); and

an intermediate chamber (**30**) disposed between the liquid chamber (**20**) and the exducer wall portion (**34**), the intermediate chamber (**30**) insulating at least of a portion of the volute (**18**) from the liquid chamber (**20**).

7. The turbocharger (**10**) of claim **6** wherein the intermediate chamber (**30**) totally encloses the volute (**18**) and completely separates the volute (**18**) from the liquid chamber (**20**).

8. The turbocharger (**10**) of claim **6** wherein the intermediate chamber (**30**) includes a passage (**40**) through the exducer wall portion (**34**) configured to permit a flow of exhaust gas into the intermediate chamber (**30**).

9. The turbocharger (**10**) of claim **8** wherein the passage (**40**) is a slot (**42**) through the exducer wall portion (**34**).

10. The turbocharger (**10**) of claim **6** wherein the intermediate chamber (**30**) includes a passage (**40**) that extends circumferentially around the exducer wall portion (**34**) downstream of the turbine wheel (**16**).

11. The turbocharger (**10**) of claim **6** wherein the intermediate chamber (**30**) includes an air-inlet passage (**40**) through the turbine housing (**12**) configured to permit a flow of air into the intermediate chamber (**30**).

* * * * *