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(54) AIR INDUCTION SYSTEM FOR SMALL WATERCRAFT

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(22) Filed: **Sep. 25, 2000**

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(52) **U.S. Cl.** **440/88**; 114/55.5
(58) **Field of Search** .... 440/88, 89, 38; 114/55.5; 123/198 A, 193.1, 193.2

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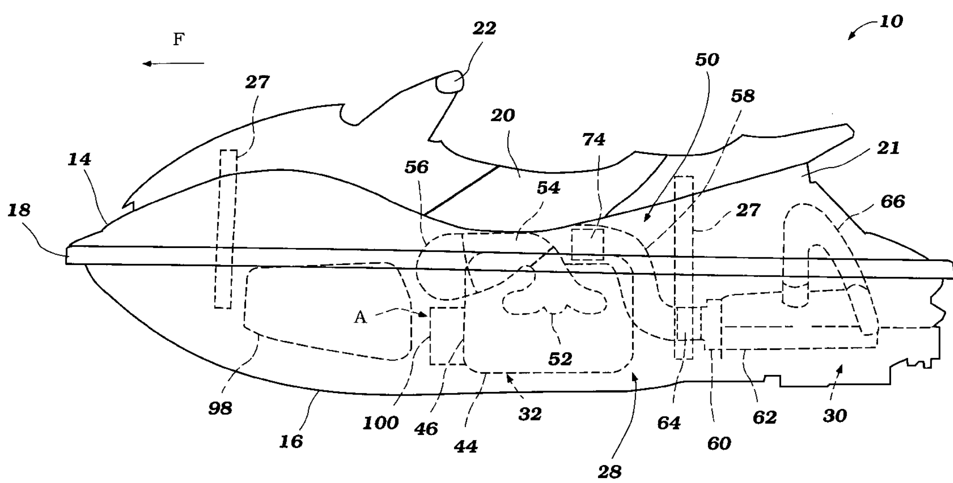
(57) **ABSTRACT**

An induction system for a watercraft includes a first intake air chamber communicating with at least one combustion chamber of an engine of the watercraft, and a second intake air chamber communicating with the first intake air chamber via a conduit. The second intake air chamber may be arranged in various orientations and/or with various other features which improve attenuation of induction noises and/or the preclusion of water from entering the engine through the induction system.

22 Claims, 9 Drawing Sheets



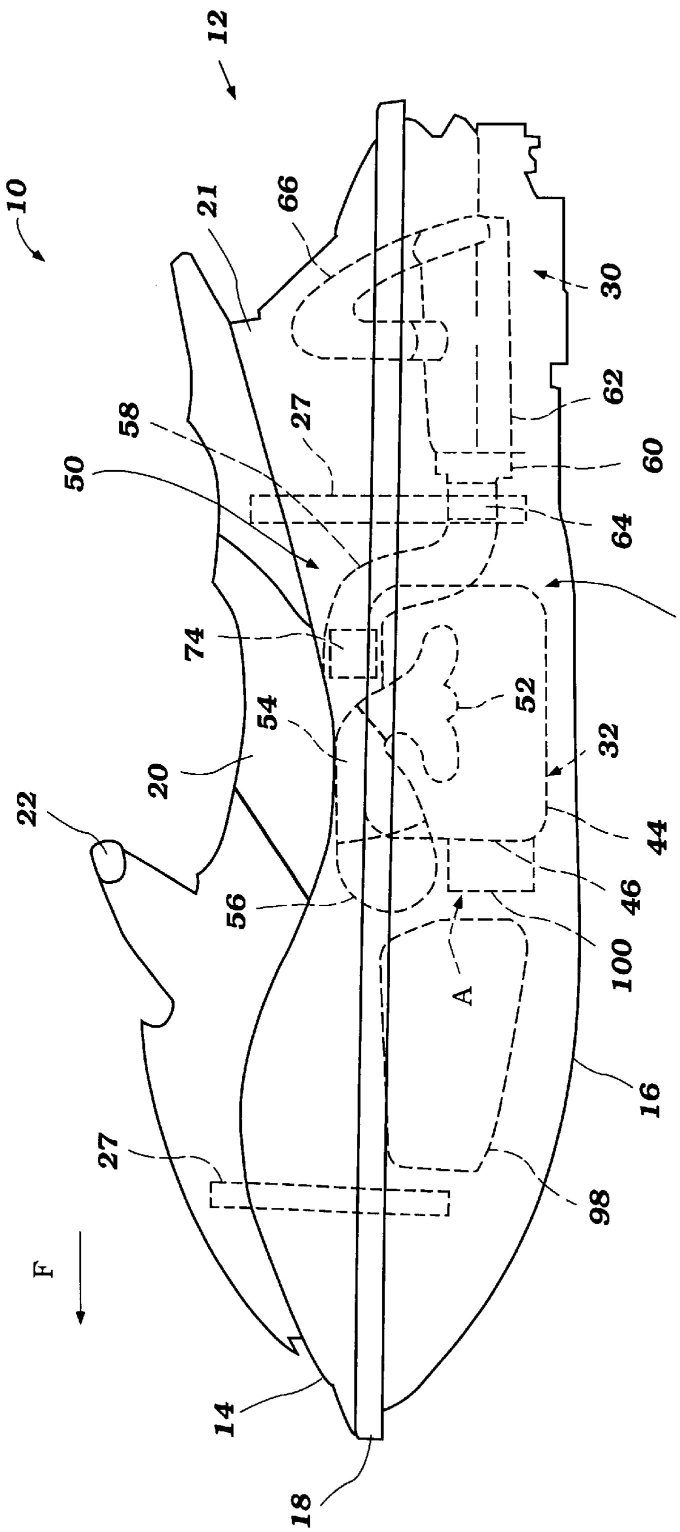

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Figure 1

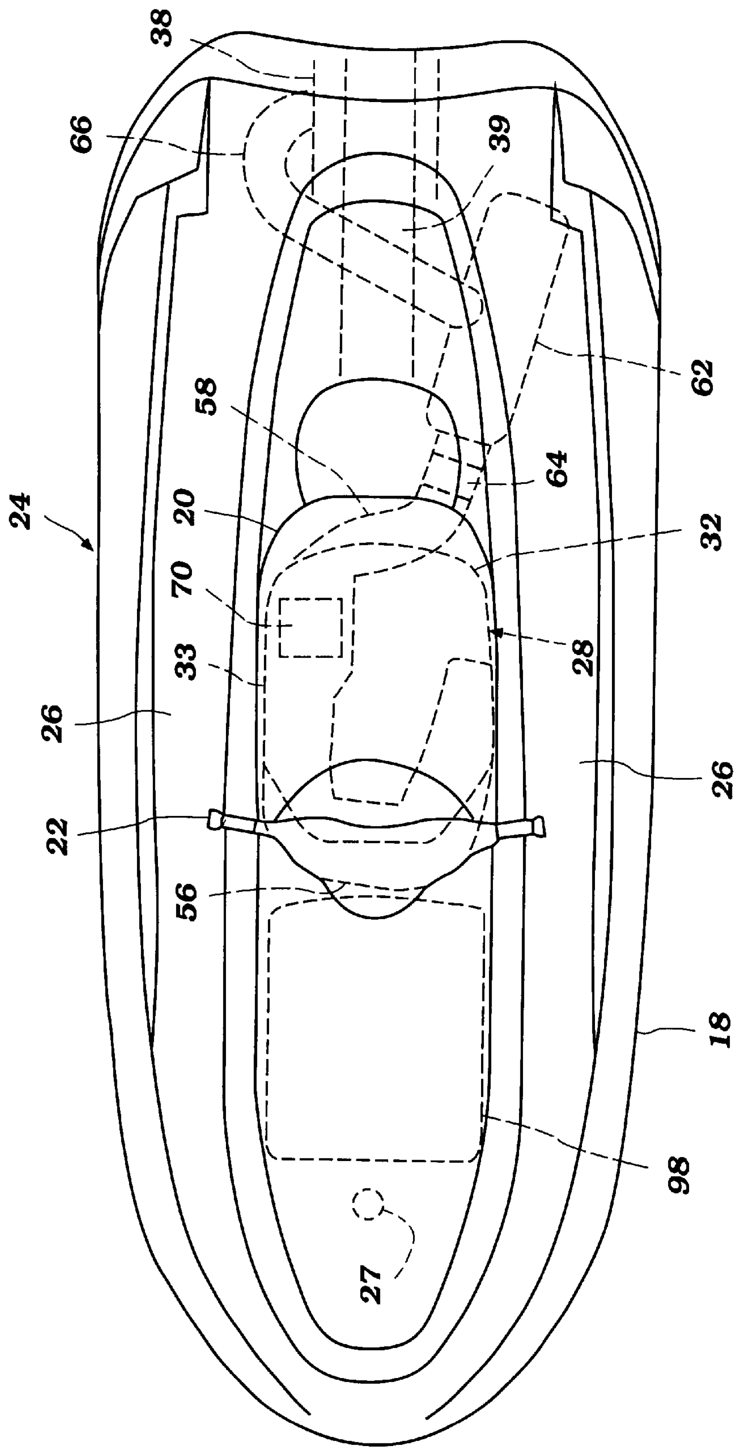

Figure 2

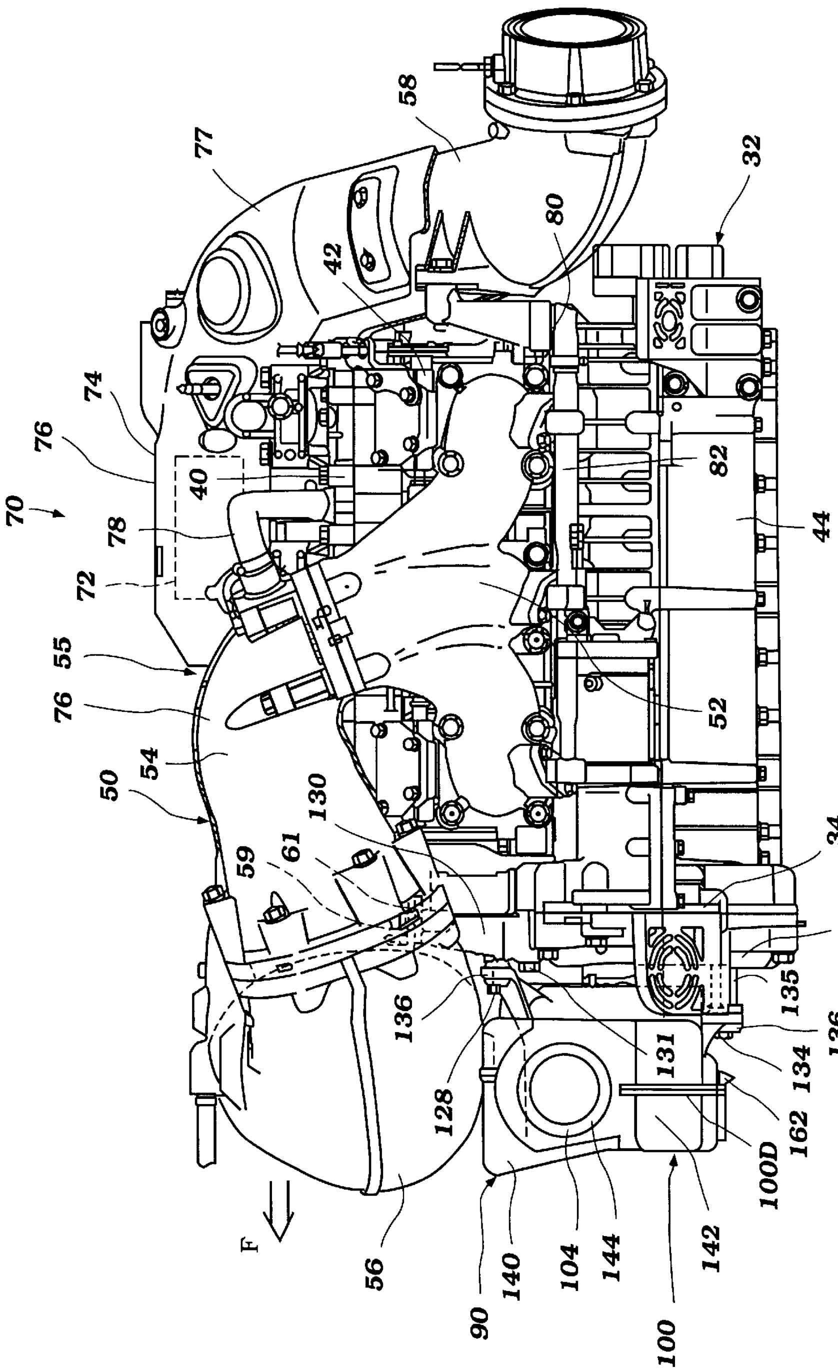

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Figure 3

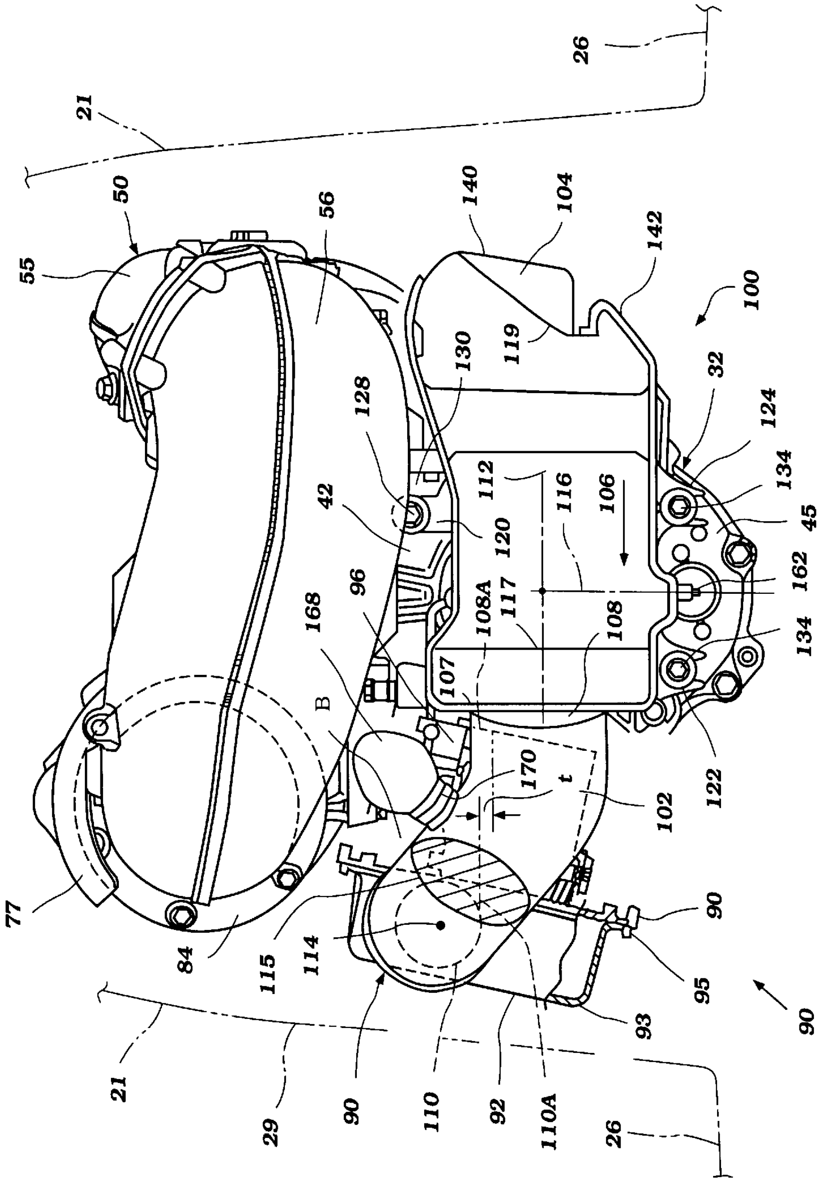
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Figure 4

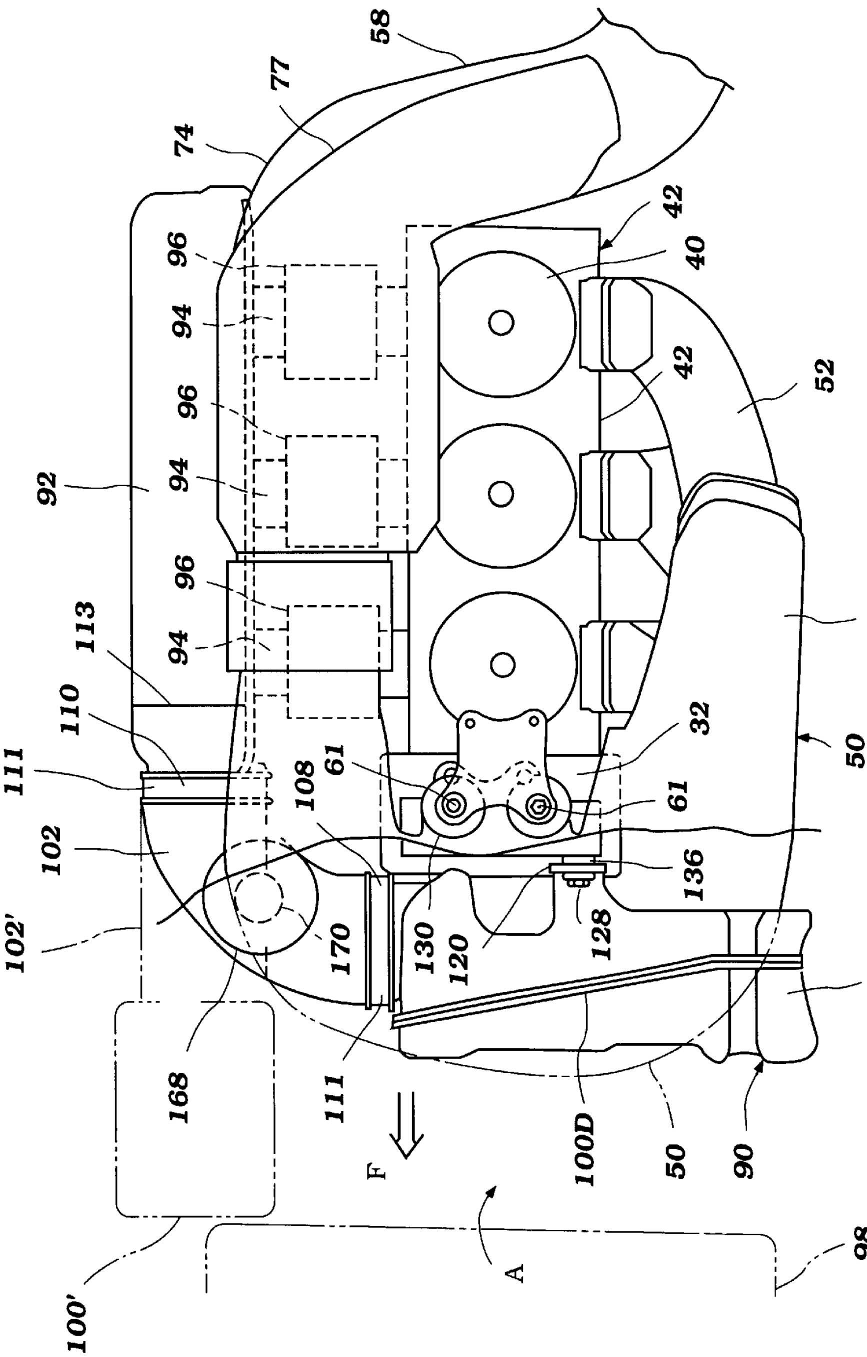
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Figure 5

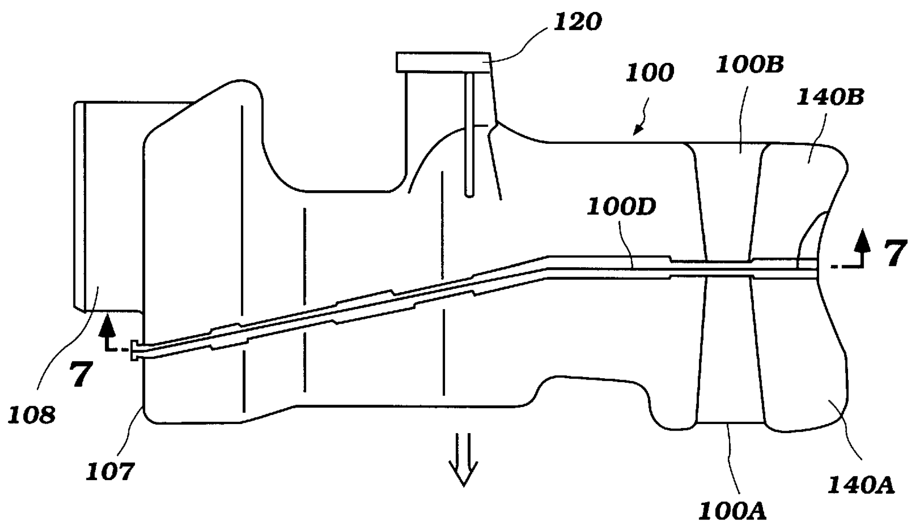

Figure 6

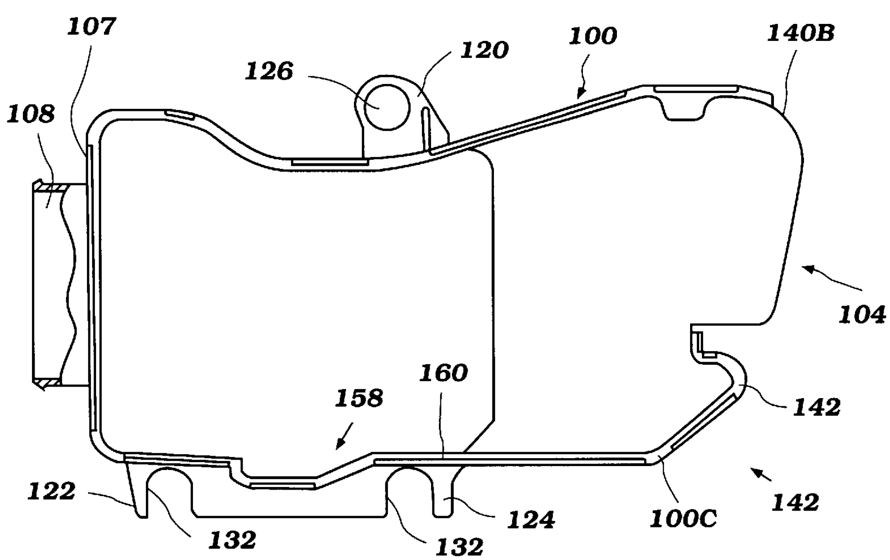

Figure 7

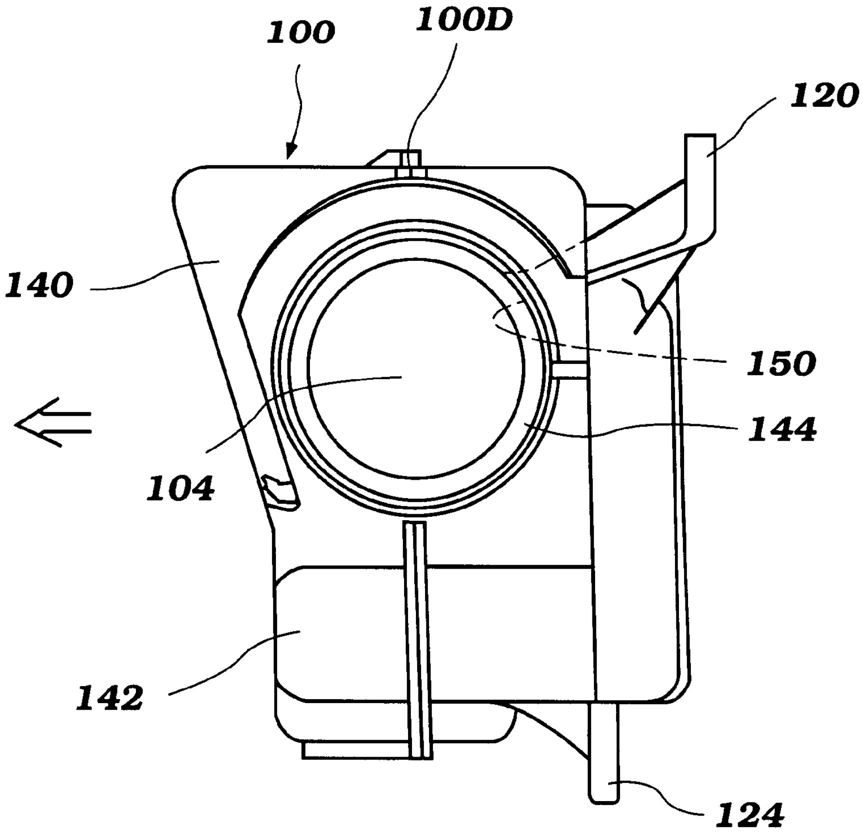

Figure 8

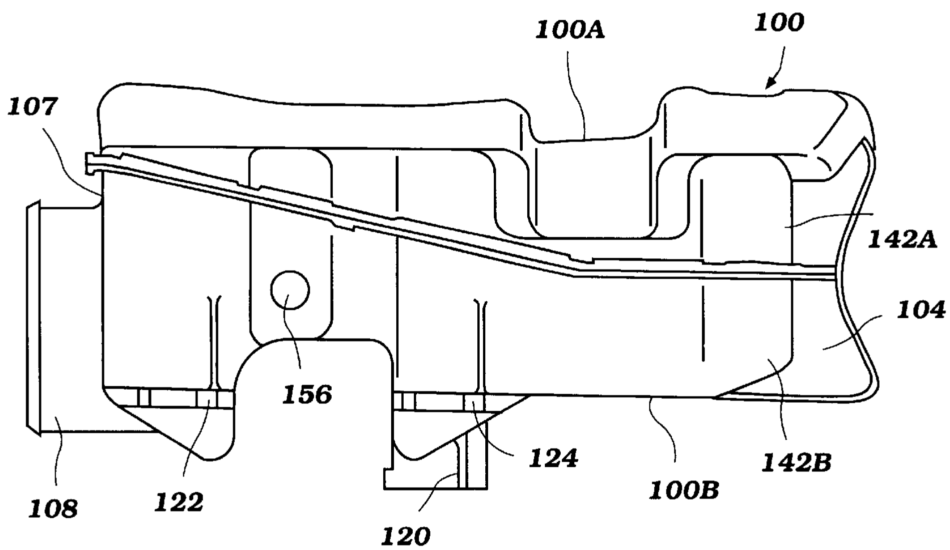

Figure 9

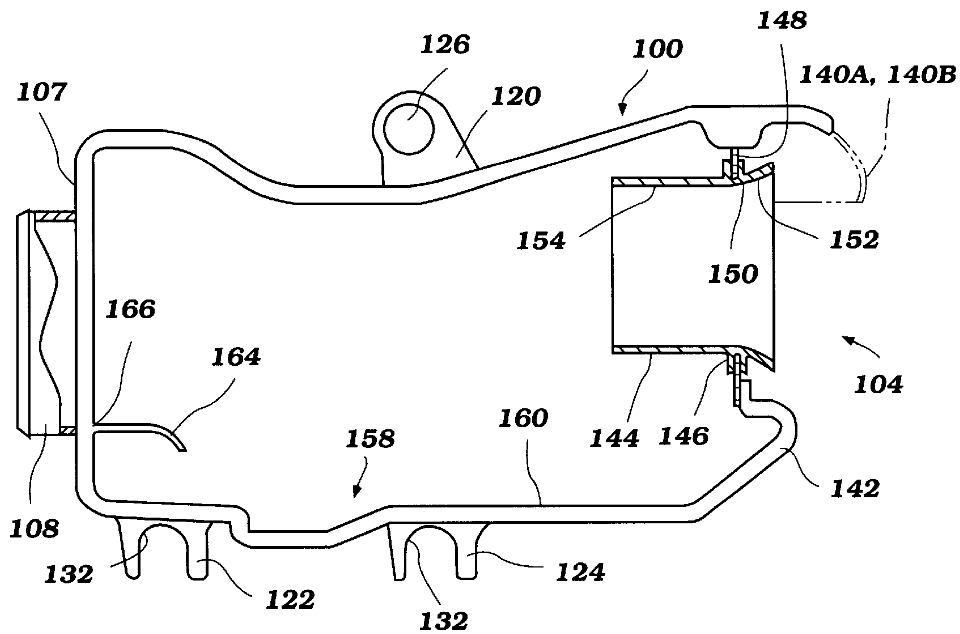

Figure 10

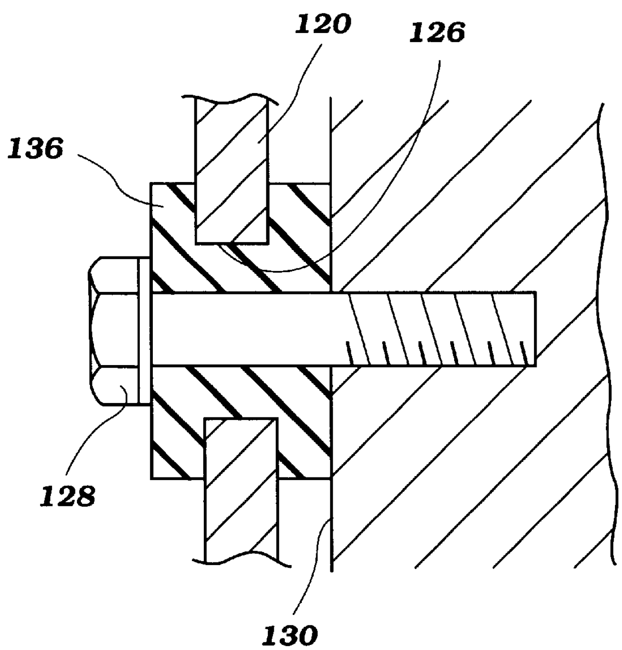

Figure 11

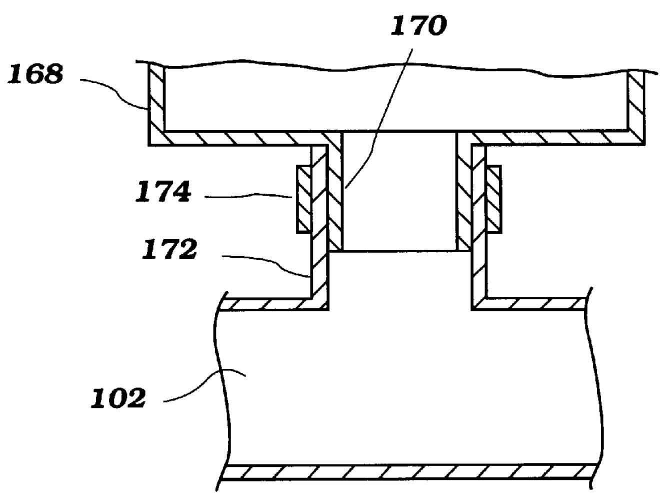

Figure 12

AIR INDUCTION SYSTEM FOR SMALL WATERCRAFT

PRIORITY INFORMATION

This application is based on Japanese Patent Application No. 11-271063 filed Sep. 24, 1999.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention is directed to a watercraft, and more particularly to a water preclusion and sound attenuation system employed in a watercraft engine induction system.

2. Description of the Related Art

Personal watercraft have become increasingly popular in recent years. This type of watercraft is sporting in nature; it turns swiftly, it is easily maneuverable, and accelerates quickly. A personal watercraft today commonly carries one rider and up to three passengers. Typically, the rider and passengers sit on a straddle-type seat that is formed by the hull of the watercraft. The straddle-type seat is generally aligned by the longitudinal axis of the hull.

The space beneath the straddle-type seat is usually used as an engine compartment for supporting the engine within the watercraft. The engine is preferably arranged within the engine compartment so that the crankshaft of the engine is aligned with the longitudinal axis of the watercraft. With the engine arranged as such, the crankshaft of the engine may be directly connected to an output shaft for driving a propulsion unit. Additionally, such an arrangement allows the engine to be arranged within the seat pedestal. Arranged as such, the engine and the seat pedestal form a compact unit. During operation, the rider and any passengers straddle the seat as well as the engine while they are seated on the straddle-type seat. With the hull shaped as such, the engine is in close spacing with the passengers during operation, thus allowing the overall size of the watercraft to remain quite small, resulting in a compact and highly maneuverable watercraft.

Although these watercraft are generally highly maneuverable and are used in a sporting manner, there is an interest in reducing the noise generated by this type of watercraft. One part of the watercraft propulsion system that can generate noise is the induction system of the engine. For the most part, the induction systems used for this type of watercraft have been designed primarily to ensure adequate air induction and at least some filtration of the inducted air. Little effort has been given, however, to the silencing of the induction system.

At least partially in response to the noise generated by two-cycle engines, which are commonly employed in personal watercraft, certain recreational facilities have banned the operation of two-cycle engine powered watercraft. Such bans have resulted in a decrease in popularity of personal watercraft powered by two-cycle engines.

Obviously, it is necessary for the induction system to be able to ingest an adequate flow of air for maximum engine performance. In many instances, the induction systems previously proposed for watercraft have not recognized the advantages of using a tuning arrangement on the intake side of the engine. One reason for this is that the space available in an engine compartment of a personal watercraft generally does not afford room for various types of intake tuning systems. Although it has been known that a large intake air box will prevent the generation of loud noises in the induction system and will generate a smooth flow of air into the combustion chambers, the small space available in the hulls of small watercraft have prevented the use of large air boxes.

For example, a large air box mounted so as to feed the intake runners arranged along one side of an engine within the engine compartment of a watercraft, will tend to attenuate induction noises. However, as discussed above, engines are preferably arranged within the engine compartments of personal watercraft such that their crankshaft is aligned with the longitudinal axis of the watercraft. As such, the intake runners open at a side of the engine, facing an inner wall of the seat pedestal. Therefore, the size of the intake air box affects the overall width of the engine. If a large intake air box is used, the overall width of the engine is increased.

Since the rider and any passengers straddle the seat pedestal and engine during operation, the overall width of the engine is limited to that which would fit within a straddle-type seat pedestal. If the pedestal is too wide, a rider cannot comfortably sit on the seat pedestal during operation of the watercraft. Therefore, any portions of the engine mounted along either side of the engine, such as the induction system, should be small enough such that the engine can still fit within the seat pedestal that defines an engine compartment of the watercraft.

Additionally, because of its sporting nature, personal watercraft are oftentimes laid on their side or are flipped over by advanced riders during use. It thus is also important that the induction system be designed in such a way to inhibit water, which may be present in the engine compartment, from passing into the engine through the induction system.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, an engine induction system for a watercraft includes a first intake air chamber having an air inlet and communicating with the at least one combustion chamber and a second intake air chamber having an air inlet and an air outlet. A conduit connects the air inlet of the first intake air chamber to the outlet of the second intake air chamber. The outlet of the second intake air chamber is positioned vertically lower than the inlet of the first intake air chamber.

By positioning the outlet of the second intake air chamber vertically lower than the inlet of the first intake air chamber, the present induction system aids in preventing water from passing into the engine through the induction system. For example, as noted above, small watercraft, such as personal watercraft, are sporting in nature, and are oftentimes driven rigorously. Water can enter the engine compartment of these watercraft in several ways. In particular, water can enter the engine compartment through air vents that allow atmospheric air to enter the engine compartment so as to feed air to the engine for combustion. Water may also enter the engine compartment through leaks that may inadvertently occur. Finally, water may enter the engine compartment when an access opening of the engine compartment is open. Thus, when the watercraft is operated in a normal fashion, the water in the engine compartment can splash vigorously therein. However, by positioning the outlet of the second intake air chamber vertically lower than the inlet of the first intake air chamber, it is more difficult for such water to pass into the engine, where the damaging and corrosive effects of water can cause significant damage requiring expensive repairs.

According to another aspect of the present invention, an engine induction system for a watercraft includes a first intake air chamber having an air inlet and communicating with the at least one combustion chamber and a second intake air chamber having an air inlet and an air outlet. A conduit connects the air inlet of the first intake air chamber to the outlet of the second intake air chamber. The conduit is sized so as to form a third air chamber. Preferably, the cross-sectional flow area of the conduit is larger than the outlet of the second intake air chamber and the inlet of the first intake air chamber. As such, the present induction system causes air flowing therethrough to contract and expand several times before entering the engine. The expansion and contraction of the air flow through the induction system quiets and smoothes the air before it enters the engine.

According to another aspect of the present invention, an engine induction system for a watercraft includes a first intake air chamber having an air inlet and communicating with the at least one combustion chamber and a second intake air chamber having an air inlet and an air outlet. A conduit connects the air inlet of the first intake air chamber to the outlet of the second intake air chamber and a branched conduit extends upwardly from the conduit. As such, the branched conduit provides a water preclusive effect when the watercraft is capsized.

For example, as noted above, personal watercraft are oftentimes capsized during normal operation. Thus, water that may be present in the engine compartment of the watercraft can flow upstream through an air induction system as the watercraft rotates toward and reaches a capsized positioned. By providing an upwardly extending branched passage from the conduit, water that travels through the conduit when the watercraft is capsized, can flow into the branched passage. Additionally, when the watercraft is returned to an upright position, the water collected in the upwardly extending passage will drain back to the conduit, thus ejecting water that had previously flowed upstream into the induction system.

Further aspects, features and advantages of the present invention will become apparent from the detailed description of the preferred embodiment which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned and other features of the invention will now be described with reference to the drawings of a preferred embodiment of the present watercraft. The illustrated embodiment is intended to illustrate, but not to limit the invention. The drawings contain the following figures:

FIG. **1** is a side elevational view of a personal watercraft in accordance with a preferred embodiment of the present invention with several internal components of the watercraft (e.g. an engine) shown in phantom line;

FIG. **2** is a top plan view of the personal watercraft shown in FIG. **1**, with certain internal components represented in phantom line;

FIG. **3** is a side elevational view of the engine of the personal watercraft shown in FIG. **1**;

FIG. **4** is a front elevational view of the engine shown in FIG. **3**, illustrating intake air chambers connected by a conduit and a resonator chamber connected to the conduit, with portions of the surrounding hull shown in phantom;

FIG. **5** is a top plan view of the engine shown in FIG. **4**;

FIG. **6** is a top plan view of one of the air intake chambers shown in FIG. **4**;

FIG. **7** is a sectional view of the air intake chamber shown in FIG. **4**, taken along line **7**—**7**;

FIG. **8** is a side elevational view of the intake air chamber shown in FIG. **7**;

FIG. **9** is a bottom plan view of the intake air chamber shown in FIG. **8**;

FIG. **10** is a partial sectional view of the intake air chamber shown in FIG. **9**;

FIG. **11** is an enlarged cross-sectional view of a coupling between the engine and the intake air chamber shown in FIG. **3**; and

FIG. **12** is a cross-sectional view of the connection between the conduit and the resonator chamber shown in FIG. **4**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGS. **1** and **2** illustrate different views of a small watercraft incorporating an induction system configured in accordance with the preferred embodiment of the present invention. The induction system includes enhanced noise attenuation and/or water preclusion characteristics, and effectively utilizes space that is typically unused within a hull of a watercraft. Although the present induction system is illustrated in connection with the personal watercraft, the illustrated induction system can be used with other types of watercraft as well, such as, for example, but without limitation, small jet boats and the like.

FIGS. **1** and **2** illustrate a watercraft **10** having a watercraft body comprising a hull **12** which is constructed of a top portion or deck **14** and a lower portion **16**. A gunnel **18** defines a intersection of the lower portion **16** and the deck **14** of the hull **12**. The watercraft **10** is suited for movement through a body of water in a direction F (towards the front end of the watercraft).

A seat **20** is positioned on a seat pedestal **21** which is formed by the deck **14** of the hull **12**. A steering handle **22** is provided adjacent the seat **20** for use by a user in directing the watercraft **10**. Preferably, a bulwark **24** is defined by the gunnel **18** and extends upwardly along each side of the watercraft **10**. A footstep area **26** is defined between the seat **20** and the bulwark **24** on each side of the watercraft **10**.

The top and bottom portions **14** and **16**, along with a bulkhead (not shown) define an engine compartment **28** and a pumping or propulsion unit compartment **30**. An engine **32** is positioned in the engine compartment **28**. With reference to FIG. **3**, the engine **32** is connected to the lower portion **16** of hull **12** with several engine mounts (not shown) which are shaped to be bolted to the lower portion **16** of hull **12** or to an insert (not shown) attached to the hull lower portion **16**.

The engine **32** is preferably at least partially accessible through a maintenance opening **33**, which itself is accessible by removing the seat **20**. As shown in FIG. **1**, the hull **12** also includes at least one intake air vent **27**, which allows air to enter the engine compartment **28**. Preferably, the hull **12** includes two intake air vents **27**, provided at the front and rear of the hull **12**, which allow air to flow through the engine compartment **28**.

The engine **32** has a crankshaft (not shown) which is located at least partially within a crankcase **44**, and which is connected to a flywheel (not shown) in a known manner. As shown in FIG. **1**, the engine **32** includes flywheel cover **46** arranged at a forward end of the crankcase **44** of the engine **32**.

The engine **32** transfers rotational energy from the crankshaft to a propulsion unit **39** provided in the propulsion unit compartment **30**. The propulsion unit **39** is provided in a tunnel **38** formed in the lower portion **16** of the hull **12**. Arranged as such, the propulsion unit **39** induces a flow of water into an inlet of the tunnel **38** and out a rear outlet of the tunnel **38** to thereby propel the watercraft **10** in a known manner.

The engine **32** preferably has two or three cylinders arranged in-line and operates on a two-cycle, crankcase compression principle. Of course, the engine **32** may have one, two, or more than three cylinders, as may be appreciated by one skilled in the art, arranged in different cylinder orientations, as well as may operate in accordance with other combustion principles (e.g., 4-cycle, diesel, and rotary principles).

With reference to FIGS. **3–5**, the engine **32** includes a cylinder head **40** that is mounted to a cylinder block **42** and cooperates therewith to define the three cylinders. A piston (not shown) is movably mounted in each cylinder and is connected to the crankshaft via a connecting rod, in a well known manner. The piston cooperates with the cylinder head **40** and a cylinder block **42** so as to define a combustion chamber portion of each cylinder.

In order to process exhaust gases discharged from the engine **32**, the watercraft **10** includes an exhaust system **50**. As shown in FIG. **1**, the exhaust system **50** includes an exhaust manifold **52** for directing the exhaust gases discharged from each of the cylinders of the engine **32** into an inlet pipe **55** forming a diverging portion **54** of an expansion chamber **56**. As shown in FIGS. **1** and **2**, the expansion chamber **56** is connected to a down-turned portion **58** which then passes through a bulkhead (not shown). As shown in FIG. **3**, the expansion chamber **56** is preferably supported by the engine **32** via an L-shaped metal bracket **59** fastened to a stay **130** with bolts **61**.

With reference to FIGS. **1** and **2**, at approximately the position of the bulkhead (not shown), the down-turned portion **58** is connected to an inlet **60** of a watertrap device **62** via a flexible connector **64** such as a rubber hose. A discharge pipe **66** extends from the water trap device **62**, over the tunnel **38**, and terminates in a wall of the tunnel **38** at a position preferably at or slightly beneath the waterline of the watercraft **10**.

In light of the recent environmental concerns raised with respect to two-cycle engine powered watercraft, the exhaust system **50** preferably includes a catalytic device **70** for removing and/or further combusting undesirable exhaust byproducts. With reference to FIG. **3**, the catalytic device **70** preferably includes a catalytic bed **72** provided within a second expansion chamber **74**. In order to control the temperature of the exhaust system, the exhaust system includes a cooling jacket **76** formed around the portion of the exhaust system **50** that is arranged within the engine compartment **28**.

For example, the cooling jacket **76** is in thermal contact with the diverging portion **54**, the expansion chamber **56** which forms a first expansion chamber, the converging portion **57**, the second expansion chamber **74**, and the down-turned portion **58**. The cooling jacket **76** is fed a coolant, such as water, from the engine **32** via pipe **78** which is connected to a cooling jacket formed around the cylinders of engine **32**. The engine **32** is supplied with coolant from an outside source, such as water from a jet pump provided in the propulsion unit **39** via inlet **80** of coolant delivery pipe **82**, in a well known manner. Additionally, in order to connect the cooling jacket **76** around the first expansion chamber **56** with the coolant jacket around the second expansion chamber **74**, a coupling **84** is provided between the first expansion chamber **56** and the second expansion chamber **74** so as to fluidly connect the portion of water-jacket **76** provided around first expansion chamber **56** with the portion of the cooling jacket **76** providing around the second expansion chamber **74**. In order to protect the cylinder head **40** from the heat discharged from the second expansion chamber **74** and the down-turned portion **58** of the exhaust system, a heat shield **77** is preferably provided around at least a portion of the second expansion chamber **74** and the down-turned portion **58**, as shown in FIGS. **3–5**.

With reference to FIGS. **1–5**, and in particular FIGS. **3–5**, the induction system **90** includes a first intake air chamber **92**. Preferably, the first intake air chamber **92** is formed of a body member **91** connected to intake runners **94**, and a cover member **93** sealedly engaged with the body member **91** along a sealing surface **95**. As shown in FIG. **4**, a dead space B is formed above the charge formers **96**, between the intake air chamber **92** and the engine **32**, and below the coupling **84**. The first intake air chamber **92** communicates with at least one combustion chamber formed in the cylinder head **40** through the intake runners **94** in a known manner.

For example, the intake runners **94** direct air into corresponding fuel charge formers **96** which mix air from the intake runners **94** with a charge of fuel for delivery into the combustion chambers of the cylinder head **40**. Although fuel injectors are preferred, carburetors and other known devices may also be used as the fuel charge formers **96**. Although it is desirable to form the first intake air chamber **92** so as to be as large as possible so as to reduce induction system noise, space within the watercraft hull **12** is limited.

For example, is as shown in FIG. **4**, if the width of the first intake air chamber **92** is increased, a side wall **29** of the seat pedestal **21**, which also forms a side wall of the engine compartment, would have to be moved outward so as to accommodate a larger first intake chamber. Additionally, a gap should be formed between the intake chamber **92** and the wall **29** so as to accommodate engine vibration relative to the wall **29**, and to avoid conduction of vibration from the engine **32** to wall **29**.

The induction system **90** includes a second intake air chamber **100** communicating with the first intake air chamber **92** via a conduit **102**. As shown in FIGS. **4** and **5**, the intake air chamber **100** includes an inlet orifice **104** which is open to the engine compartment. The chamber **100** communicates with the conduit **102** through an outlet **108** formed in a side wall **107** of the chamber **100**.

With reference to FIG. **5**, the conduit **102**, at a downstream end in the direction of air flow, is connected to an inlet **110** of the first intake air chamber **92**. The conduit **102** preferably is constructed of a flexible material such as rubber, and is connected to the outlet **108** and the inlet **110** with band clamps **111**.

In operation, ambient air from the engine compartment **28** enters the induction system **90** via the inlet **104**. Air then flows through the chamber **100** in the direction of arrow **106** until it reaches an outlet **108**. The flow of induction air enters the conduit **102** through the outlet **108** of the chamber and continues to the inlet **110** of the air intake chamber **92**. As the air flow passes through the chamber **92**, the air flow is distributed to the intake runners **94**.

Constructed as such, the second intake air chamber **100**, the conduit **102**, and the first intake air chamber **92** define an induction air flow path for air entering the engine **32** for combustion purposes. Furthermore, by constructing the induction system **90** in the form of a first chamber connected to a second chamber by a conduit, the induction system **90** provides for the efficient use of the relatively small amount of space available in a small watercraft.

For example, as is illustrated in FIG. **4**, the engine compartment **28** is nearly completely filled by the engine **32**. The width of the engine **32** is nearly as wide as the engine compartment **28**, along a direction transverse to the longitudinal direction of the watercraft **10**. Additionally, as shown in FIG. **5**, the engine **32** is in close proximity to the fuel tank **98**. Because the engine compartment **28** is positioned generally below the seat **20**, the maximum width of the engine compartment **28** is quite limited. For example, since the passengers of the watercraft **10** sit directly above the engine **32**, and on the seat **20** in a straddle-type fashion, the width of the engine compartment **28** is limited to that which is appropriate for a width of a straddle-type seat assembly such as the seat **20**. Therefore, by providing the induction system **90** with a first intake air chamber **92** and a second intake air chamber **100**, which communicate with each other so as to define an induction air flow path, the present induction system **90** allows the second intake air chamber **100** to be arranged remotely from the first intake air chamber **92**, thusly efficiently using the space available within the engine compartment **28**.

The second intake air chamber **100** is preferably mounted between the engine **32** and the fuel tank **98**, as shown in FIGS. **1** and **5**. Arranged as such, the induction system **90** utilizes a space which has heretofore gone unused win the hulls of known personal watercraft.

As shown in FIG. **4**, the outlet **108** of the intake air chamber **100** has a center line **112** defining a center of the outlet **108**. Additionally, the inlet **110** includes a center **114** which lies on a centerline of the inlet **110**. As shown in FIG. **4**, the center **114** of the inlet **110** is provided at an elevation higher than an elevation of center line **112** of outlet **108**. Therefore, if water inadvertently enters the intake air chamber **100**, it is unlikely that such water can flow upwards through the conduit **102** into the intake air chamber **92**.

With reference to FIG. **4**, in accordance with an aspect of the present invention, a lower edge **110**A of the inlet **110** of the first intake chamber **92** is positioned vertically higher than an upper edge **108**A of the outlet **108** of the second intake chamber **100**. The lower edge **110**A is vertically higher than the upper edge **108**A by distance t.

By positioning the lower edge **110**A of the inlet **110** above the upper edge **108**A of the outlet **108**, the present induction system **90** further ensures that water that may flow from the first air intake chamber **100** and through the outlet **108** does not reach the inlet **110** of the air intake chamber **92**.

As shown in FIG. **4**, the engine **32** has a center line **116** along which the crankshaft (not shown) and the flywheel (not shown) are aligned. Preferably, the inlet orifice **104** of the intake air chamber **100** is positioned so as to be on the side of the center line **116** that is opposite of the intake air chamber **92**. However, the intake chamber **100** and the conduit **102** of the induction system **90** may be arranged as chamber **100'** and conduit **102'** as shown in FIG. **5**. In either orientation, the chamber **100** or **100'** are arranged between the engine **32** and the fuel tank **98**. By positioning the intake air chamber **100** or **100'** as such, the induction system **90** effectively utilizes a dead space A that has heretofore gone unused in the engine compartments of small watercraft such as personal watercraft.

With reference to FIGS. **4** and **5**, the induction system **90** preferably defines an induction air flow path that contracts and expands along its length. For example, as shown in FIG. **5**, the first intake air chamber **92** defines a maximum cross-sectional air flow area **113** that is defined along a plane generally perpendicular to the direction of air flow into the first intake air chamber **92**. As shown in FIG. **4**, the conduit **102** defines a cross-sectional flow area **115** which is smaller than the cross-sectional flow area **113**.

The second intake air chamber **100** defines a maximum cross-sectional air flow area **117** along a plane generally perpendicular to the flow of air **106** through the second intake air chamber **106**. The cross-sectional air flow area **117** preferably is larger than the cross-sectional air flow area **115**. The inlet **104** similarly defines a cross-sectional air flow area **119** that is smaller than the cross-sectional air flow area **117**.

In operation, a flow of air into the induction system **90** contracts and expands as it flows therethrough. For example, as air from the engine compartment **42** enters the inlet **104**, the air flow accelerates as it passes through the cross-sectional air flow area **119**. As the air flow moves past the cross-sectional air flow area **119** and through the cross-sectional air flow area **117**, the air flow expands and therefore slows. As such, the air flow is quieted and smoothed by the contraction and expansion. Similarly, as the air flow leaves the second intake air chamber **100** and enters the conduit **102**, the air flow is contracted and therefore accelerated, since the cross-sectional air flow area **115** of the conduit **102** is smaller than the cross-sectional air flow area **117**. As the air flow exits the conduit **102** and enters the first intake air chamber **92**, the cross-sectional air flow area of the air flow expands generally to the size and shape of the cross-sectional air flow **113** defined within the first intake air chamber **92**. Accordingly, the air flow is expanded, thereby slowing the air flow which further quiets and smoothes the air flow.

With reference to FIG. **4**, by positioning the second intake air chamber **100** so as to cross the centerline **116**, the second air intake chamber **100** can be made longer. This is beneficial for the induction system **90** because if an inlet and an outlet of an air intake chamber such as the inlet **104** and outlet **108** of the air intake chamber **100**, are positioned too closely, the air flow between the inlet **104** and the outlet **108** may not expand to the maximum cross-sectional area of the chamber, such as the cross-sectional area **117**. However, by positioning the air intake chamber **100** so that it can be made longer, the inlet **104** and the outlet **108** can also be made larger without preventing the air flow therebetween from expanding to the maximum cross-sectional area **117**.

Using a large outlet such as the outlet **108** on the air chamber **100**, also accommodates the use of a large conduit such as the conduit **102** extending between the outlet **108** and the inlet **110**. In the presently preferred embodiment, as illustrated in FIG. **4**, the conduit **102** can be sized such that the conduit **102** itself forms a third intake air chamber. Preferably, the inner cross-sectional area **115** of the conduit **102** is larger than the cross-sectional area of the outlet **108** and the cross-sectional area of the inlet **110**. Thus, the air flow also expands as it enters the conduit **102** and contracts as it passes through the inlet **110**, thus further smoothing and silencing the air flow through the induction system **90**.

Additionally, as shown in FIG. **5**, at least a portion of the induction system **90** is configured so as to shield at least one of the charge forming devices **96** from being splashed with water. As is apparent from FIG. **5**, with the fuel charge forming devices **96** arranged between the body of the engine **32** and the intake air chamber **92**, the sides of the fuel charge forming devices are exposed and vulnerable to being splashed with water, which may be splashed within engine compartment **28** and towards the aft of watercraft **10**. Therefore, by arranging at least part of the induction system **90** so as to shield at least one of the fuel charge forming devices **96** from being splashed with water, the induction system **90** aids in preventing the corrosive and damaging effects of water splashing on the fuel charge formers **96**.

For example, water from the bodies of water in which watercraft **10** may be operated, and particularly sea water, causes accelerated corrosion of metals and rubber, as well as material used in gaskets provided between the fuel charge formers **96** and an intake manifold of the engine **32**. However, with the conduit **102** and/or the intake air chamber **102** arranged on the exposed side of the fuel charge forming devices **96**, the risk that water splashing in the engine compartment **28** may reach the fuel charge formers **96** is reduced. As shown in FIG. **5**, the conduit **102** may be curved around the exposed side of fuel charge former **96**, so as to at least partially surround the fuel charge former **96**, thereby shielding the fuel charge former **96** from being splashed with water moving towards the aft of watercraft **10**. Alternatively, the intake air chamber **100'** and the conduit **102'** may be arranged so as to create a shield for the exposed side of the fuel charge former **96**, as shown in FIG. **5**.

As is apparent from FIGS. **1** and **3–5**, at least a portion of the exhaust system **50** preferably extends between the engine **32** and the fuel tank **98**, generally above induction system **90**. In this configuration, the total height of the engine is minimized.

As shown in the figures, although the upper edge **108**A is positioned below the lower edge **110**A, the induction system **90** defines a generally horizontal intake air flow path. The exhaust system **50**, and in particular, the expansion chamber **56**, extends generally parallel and above the induction system **90**. Arranged as such, the exhaust system **50** and the induction system **90** cooperate to provide an effective shield against splashing water from reaching the fuel charge formers **90**. Additionally, since the exhaust system **50**, and particularly the expansion chamber **56**, are quite hot during operation of the watercraft **10**, water that is splashed on the exhaust passage **58** or the expansion chamber **56** is quickly vaporized, thereby preventing water from reaching the charge forming devices **96**. Additionally, with the induction system **90** arranged below the exhaust passage **58**, drips of water that may not have been vaporized by the exhaust passage **58**, will be blocked from reaching the fuel charge formers **96**, thereby reducing the likelihood that water may reach the fuel charge formers **96**.

It has been found that users can be required to perform maintenance on the engine of a small watercraft, such as the watercraft **10**, while the watercraft **10** is floating in a body of water. For example, sparkplugs of an engine, such as the engine **32**, may become fouled during operation of the watercraft **10**. Thus, in order to change the sparkplugs or restore them to an operational state, a user can remove the seat **20** from the seat pedestal **21** and remove sparkplugs (not shown) mounted to the cylinder head **40**, while the watercraft **10** is floating on a body of water. However, it has been found that when the seat **20** is removed from the seat pedestal, thus opening the access opening **33**, water from the body of water in which the watercraft **10** is operating, can splash into the access opening **33** and onto the engine **36**. Additionally, the seat **20** may be wet when the user removes it from the seat pedestal **21**. Accordingly, water may drip off of the seat **20** as the operator removes it from the access opening **33**, further dripping water onto the engine **36**. Thus, by arranging at least a portion of the exhaust system **50** over the induction system **90**, the induction system **90** is further protected from dripping water. This is particularly advantageous because, with reference to FIGS. **7** and **8**, the first intake air chamber is made from a front member **100**A and rear member **100**B each of which include sealing surfaces **100**C which sealedly engage each other and form a seal **100**D. With reference to FIG. **5**, the seal **100**D between the front and rear members **100**A, **100**B, is positioned beneath a portion of the exhaust system **50**. As noted above, because the exhaust system is typically hot during operation of the watercraft **10**, water droplets that may drip through the access opening **33** onto the exhaust system **50**, are quickly vaporized. Thus, the exhaust system **50** further protects the seal **100**D.

Although it has been known to provide a gap between an engine and fuel tank of a personal watercraft in order to prevent the overheating of fuel in the fuel tank, the volume of space generated in the gap has not been effectively used. Furthermore, due to the limited space available in engine compartments of small watercraft, little progress has been made in quieting the induction systems of engines provided in small watercraft. Therefore, by providing the induction system **90** with an intake air chamber such as the intake air chambers **100** or **100'** provided between the engine **32** and the fuel tank **98**, the induction system **90** achieves the dual goals of providing an additional intake air chamber for quieting the induction system **90** and effectively using a volume of dead space A in the engine compartment **28** which has heretofore gone unused.

In a presently preferred embodiment, the intake air chamber **100** is mounted to the engine **32**. For example, as shown in FIGS. **3–7**, the intake air chamber **100** includes at least one bracket **120** for mounting the chamber **100** to the engine **32**. Preferably, the chamber **100** includes a plurality of brackets **120**, **122**, **124** which are adapted to receive a fastener for securing the chamber **100** to the engine **32**. For example, as shown in FIGS. **5** and **8**, the bracket **120** includes a through hole **126** through which a bolt **128** passes in order to secure the bracket **120** to the stay **130**. The stay **130** is mounted to the engine **32** with at least one bolt **131** and is preferably formed of a heat resistant material such as an aluminum alloy, for example. Alternatively, the brackets **120**, **122** and **124** may have an alternate construction. For example, as shown in FIGS. **4**, **10**, and **11**, the brackets **122** and **124** may include open slots **132** which are sized to receive threaded fasteners, such as bolts **134**.

By mounting the intake air chamber **100** to the engine **32**, several desirable advantages are achieved. For example, since it is common in the watercraft industry to assemble powerplants such as internal combustion engines, at sites remote from the site where final assembly of the engine with the watercraft is performed, special care and procedures should be taken to prevent damage, and during final assembly. Therefore, by mounting the intake air chamber **100** to the engine **32**, the level of care required for ensuring that the intake air chamber **100** is not damaged during transportation is substantially reduced. Additionally, with the intake air chamber **100** mounted to the engine **32**, no additional steps are required during assembly to mount the intake air chamber **100** to the hull **12**.

Preferably, the intake air chamber **100** is mounted to the engine **32** via an elastic member such as grommets **136**. The grommets are preferably formed of an elastic and heat resistant material such as rubber. Constructed as such, the grommets **136** and/or open slots **132** form vibration isolation couplings which attenuate vibration conducted to the intake air chamber **100** from the engine **32**. By mounting the intake air chamber **100** to the engine **32** with such elastic members, several desirable advantages are achieved.

For example, by attenuating the vibration conducted to the intake air chamber **100** from the engine **32**, additional noise that would be generated by the resonance of the walls of the intake air chamber **100** is avoided. Furthermore, if heat is allowed to be conducted into the intake air chamber **100**, which would therefore be conducted into the air flowing into the induction system **90**, the air may be undesirably expanded, thereby affecting the fuel-to-air ratio delivered to the combustion chambers of the engine **32**. Therefore, by mounting intake air chamber **100** with elastic members **136** as such, undesirable noise and heat are avoided.

As shown in FIGS. **3** and **4**, the bolts **134** may be secured to the flywheel cover **46** via a boss **135**. By securing the bolts **134** as such, the complexity of the design of the cylinder head **40** can be simplified. For example, at any position on the cylinder head **40** where a threaded aperture is provided for receiving a threaded fastener such as a the bolts **134**, it is advisable to ensure that a cooling jacket provided in the cylinder head **40** is not punctured during the machining of the threaded aperture. However, since the flywheel cover **46** provided on the lower portion of the engine **32** does not typically include a cooling jacket, it may not be as difficult to provide a threaded fastener on the flywheel cover **46** since there is no danger that a cooling jacket will be punctured.

With reference to FIGS. **6** and **7**, the front and rear members **100**A, **100**B of the intake air chamber **100** preferably include a visor portion **140**A, **140**B, respectively. These visor portions **140**A, **140**B cooperate to form an upper visor **140** extending generally over the inlet **104** of the first intake air chamber **100**. As such, dripping or splashing water that may fall towards the inlet **104** can be prevented from entering the intake air chamber **100**.

As shown in FIGS. **7** and **10**, the air intake chamber also preferably includes a, lower visor **142**. In the illustrated embodiment, the lower visor **142** is formed of lower visor portion **142**A and lower visor portion **142**B formed on the outer and inner members **100**A, **100**B, respectively. As shown in FIG. **10**, the lower portion **142** extends outwardly from the inlet **104** so as to further protect the inlet **104** from splashing water within the engine compartment **28**.

With reference to FIGS. **8** and **10**, a presently preferred embodiment of the intake air chamber **100** includes an air inlet sleeve **144** positioned in the inlet **104**. In the illustrated embodiment, the inlet sleeve **144** is annular in shape and is sealedly engaged with the inlet **104** around its outer surface. In this embodiment, the outer surface of the inlet sleeve **144** includes an annular channel **146**. Additionally, an inlet aperture **150**, to which the channel is engaged, is defined by an inlet plate **148**. The channel **146** engages the inner periphery of the aperture **150** to sealedly engage the outer periphery of the sleeve **144** with the plate **148**.

The inlet sleeve **144** includes an external portion **152** which is trumpet-shaped and an internal portion **154** which extends into the interior of the intake air chamber **100**. As such, the sleeve **144** aids in smoothing and quieting a flow of intake air into the air intake chamber **100**.

The intake air chamber **100** also preferably includes a drain **156**, as shown in FIG. **9**. The drain **156** is preferably provided within a recess **158**, defined in a lower surface **160** of the interior of the intake air chamber **100**. By providing the drain **156** within the recess **158**, the intake air chamber **100** may be drained of water that may have inadvertently splashed into the orifice **104**, thereby preventing the excessive buildup of water within the induction system **90**, which may eventually be fed into the combustion chambers of the engine **32**.

Preferably, the drain **156** is provided with a checkvalve **162** which is configured to allow water to drain from the intake air chamber **100**. Alternatively, the drain **156** may be connected to an active sump system for removing water from the engine compartment **28** of the watercraft **10**.

Also preferably, the outlet **108** of the intake air chamber **100** includes a rib **164** extending from a lower edge **166** of the outlet **108** and into the interior of the intake air chamber **100**. Arranged as such, if an excessive amount of water has been accumulated in the interior of the intake air chamber **100**, and is shifted violently during normal operation of the watercraft **10**, the rib **164** reduces the likelihood that water may flow through the outlet **108** and into the conduit **102**.

With reference to FIGS. **4** and **5**, the induction system **90** preferably includes a branched intake air chamber **168** communicating with the air flow path of the induction system **90**. In the illustrated embodiment, the branched intake air chamber **168** communicates with the conduit **102** through a branch conduit **170**. Preferably, the chamber **168** and the conduit **170** are configured so as to form an Helmholtz resonator wherein the chamber **168** forms a resonator chamber and the conduit **170** forms a throat. As is known in the art, a Helmholtz resonator can be tuned so to provide sound attenuation over a desired sound range. Preferably, the chamber **168** and throat **170** are tuned to attenuate sound at about 360 Hz.

As shown in FIG. **4**, the chamber **168** is preferably mounted so as to extend upwardly form the conduit **102**. For example, as shown in FIG. **12**, the throat **170** can be slip fit into a branch portion **172** of the conduit **102**. A band **174** can be fit and/or tightened around the branch conduit **172** so as to sealedly engage the throat portion **170**.

By arranging the chamber **168** so as to extend upwardly from the conduit **102**, the chamber **168** further protects the engine from the influx of water. For example, small watercraft are sometimes capsized during operation. When such a watercraft, such as the watercraft **10**, is capsized, any water in the air intake chamber **100** might flow upstream through the induction system **90** towards the intake runners **94**, through the charge formers **96**, and possibly into the combustion chambers defined within the cylinder block **42**. However, water travelling from the air intake chamber **100** through the conduit **102**, when the watercraft **10** is capsized, would be diverted into the chamber **168**, since, when capsized, the chamber **168** would extend downwardly from the conduit **102**. Thus, water can be temporarily trapped when the watercraft **10** is capsized and thus, prevented from reaching the first intake air chamber **92**.

Additionally, when the watercraft **10** is righted, any water trapped in the chamber **168** will flow back into the conduit **102** and eventually lead the induction system **90** through the drain **156**. Thus, by positioning the chamber **168** as such, the chamber **168** can collect water when the watercraft **10** is inverted and drain such water when the watercraft resumes its normal upright position.

Accordingly, although this invention has been described in terms of certain preferred embodiments, other embodiments apparent to those of ordinary skill in the art are also within the scope of this invention. Of course, a watercraft need not include all of these features to appreciate some of the aforementioned advantages associated with the present watercraft. Accordingly, the scope of the invention is intended to be defined only by the claims that follow.

What is claimed is:

1. An engine induction system for a watercraft comprised of a hull defining an engine compartment, an internal combustion engine having at least one combustion chamber and being supported within the engine compartment, and a propulsion device supported by the hull and driven by the engine to propel the hull, the induction system comprising a first intake air chamber having an air inlet and communicating with the at least one combustion chamber, a second intake air chamber having an air inlet and an air outlet, a conduit connecting the air inlet of the first intake air chamber to the outlet of the second intake air chamber, the outlet of the second intake air chamber being positioned vertically lower than the inlet of the first intake air chamber, and a branched passage extending upwardly from the conduit.

2. An engine induction system as set forth in claim **1**, wherein the outlet of the second intake air chamber being positioned completely vertically lower than the inlet of the first intake air chamber.

3. An engine induction system as set forth in claim **1**, wherein the outlet of the second intake air chamber includes an upper edge and the inlet of the first intake air chamber includes a lower edge positioned vertically higher than the upper edge of the outlet of the second intake air chamber.

4. An engine induction system as set forth in claim **1**, wherein the conduit has a cross-sectional air flow area that is less than a maximum cross sectional flow area of the second chamber.

5. An engine induction system as set forth in claim **1**, wherein the conduit has a cross-sectional air flow area that is larger that the outlet of the second intake air chamber.

6. An engine induction system as set forth in claim **5**, wherein the cross-sectional air flow area of the conduit is larger that the inlet of the first intake air chamber.

7. An engine induction system as set forth in claim **1**, wherein the conduit forms a third intake air chamber.

8. An engine induction system as set forth in claim **1**, wherein the branched passage is configured to collect water flowing through the conduit when the watercraft is capsized and to drain the water back to the conduit when the watercraft is upright.

9. An engine induction system as set forth in claim **1**, wherein the branched passage is configured to form a Helmholtz resonator.

10. An engine induction system as set forth claim **1**, additionally comprising a trumpet-shaped inlet sleeve defining the inlet to the second intake air chamber.

11. An engine induction system for a watercraft comprised of a hull defining an engine compartment, an internal combustion engine having at least one combustion chamber and being supported with the engine compartment, and a propulsion device supported by the hull and driven by the engine to propel the hull, the induction system comprising a first intake air chamber having an air inlet and communicating with the at least one combustion chamber, a second intake air chamber having an air inlet and an air outlet, a conduit connecting the air inlet of the first intake air chamber to the outlet of the second intake air chamber, the conduit forming a third intake air chamber, and a branched passage extending upwardly from the conduit.

12. An engine induction system as set forth in claim **11**, wherein the branched passage is configured to collect water flowing through the conduit when the watercraft is capsized and to drain the water back to the conduit when the watercraft is upright.

13. An engine induction system as set forth in claim **11**, wherein the branched passage is configured to form a Helmholtz resonator.

14. An engine induction system for a watercraft comprised of a hull defining an engine compartment, an internal combustion engine having at least one combustion chamber and being supported within the engine compartment, and a propulsion device supported by the hull and driven by the engine to propel the hull, the induction system comprising a first intake air chamber having an air inlet and communicating with the at least one combustion chamber, a second intake air chamber having an air inlet and an air outlet, a conduit connecting the air inlet of the first intake air chamber to the outlet of the second intake air chamber, and a branched passage extending upwardly from the conduit.

15. An engine induction system as set forth in claim **14**, wherein the branched passage is configured to collect water flowing through the conduit when the watercraft is capsized.

16. An engine induction system as set forth in claim **15**, wherein the branched passage is configured to drain the water back to the conduit when the watercraft is upright.

17. An engine induction system as set forth in claim **15**, wherein the branched passage is connected to the conduit via a throat.

18. An engine induction system as set forth in claim **15**, wherein the branched passage and the throat are configured to form a Helmholtz resonator.

19. An engine induction system as set forth in claim **14**, additionally comprising a trumpet-shaped inlet sleeve defining the inlet to the second intake air chamber.

20. An engine induction system for a watercraft comprised of a hull defining an engine compartment, an internal combustion engine having at least one combustion chamber and being supported within the engine compartment, and a propulsion device supported by the hull and driven by the engine to propel the hull, the induction system comprising a first intake air chamber having an air inlet and communicating with the at least one combustion chamber, a second intake air chamber having an air inlet and an air outlet, a conduit connecting the air inlet of the first intake air chamber to the outlet of the second intake air chamber, and means for collecting water from the induction system when the watercraft is capsized and for draining the collected water when the watercraft is upright.

21. An engine as set forth in claim **20**, wherein the second intake air chamber includes a lower wall having a recess adjacent the outlet of the second intake air chamber, a drain port provided in the recess.

22. An engine as set forth in claim **21** additionally comprising a check valve provided in the drain port.

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