United States Patent [19]

Zovko

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[54] **THRUST AUGMENTING EXPANSION ENGINE**

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[21] Appl. No.: **701,813**

[52] **U.S. Cl.** ..... **114/20 A,** 60/222, 60/248

[51] **Int. Cl.** .. **F42b 19/12,** F42b 19/18, F42b 19/22

[58] **Field of Search** 114/20; 60/217, 221, 60/222; 115/14

[56] **References Cited**

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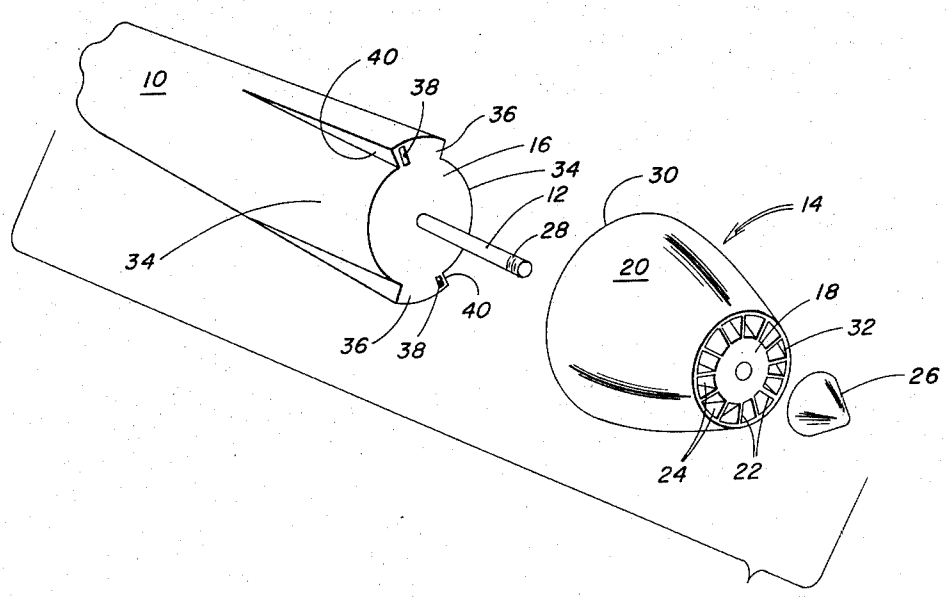
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[57] **ABSTRACT**

An expansion engine capable of extracting energy from an expanding gas and distributing that energy between the gas and a fluid stream to generate a propulson or power force. The engine includes a thrustor mounted for rotation about a shaft and consisting of a hub and a concentric shroud connected by a number of evenly spaced, helical vanes. The vanes divide the annular space between the hub and shroud into equal sized helical channels which are open at both ends. The forward ends of the channels are open during a portion of the rotation and closed during a second portion of the rotation. The channels are filled with fluid when in the unobstructed position, and an expandable gas is delivered behind each slug of fluid in the channel when in the obstructed position. The high pressure gas accelerates the already moving water to the rear of each channel.

26 Claims, 10 Drawing Figures



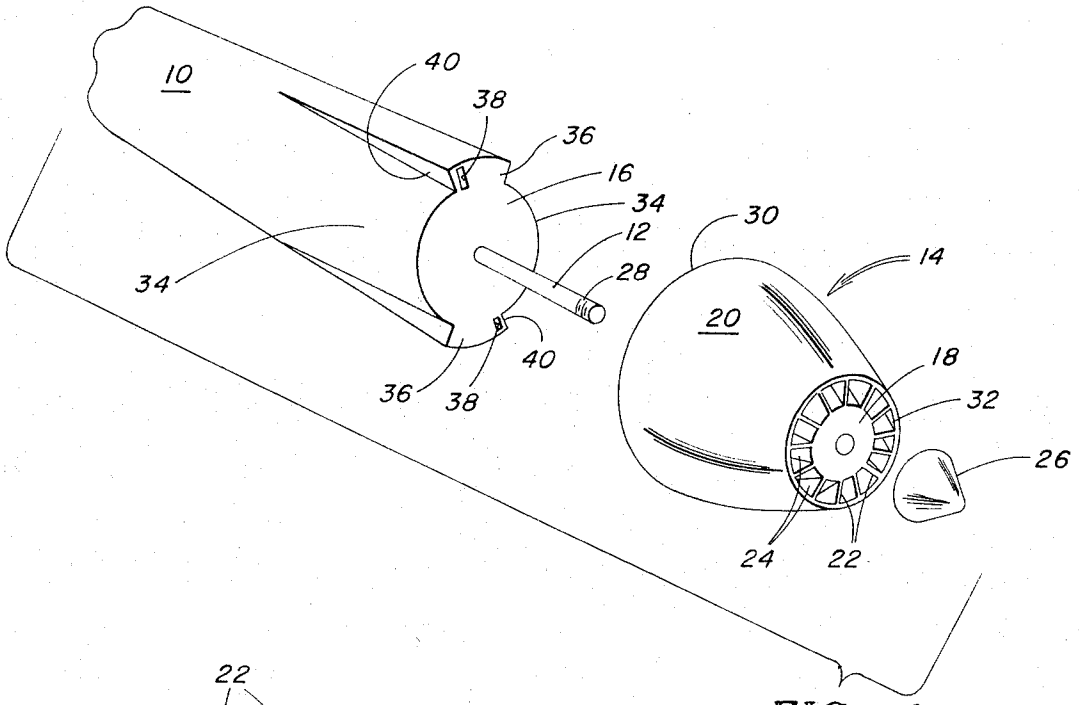


FIG. 1

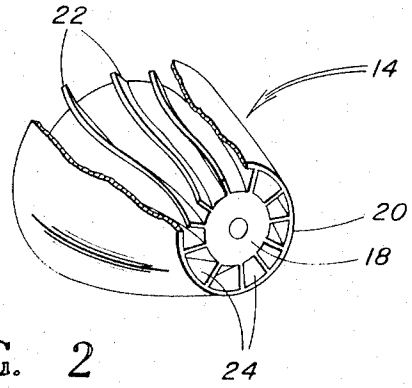


FIG. 2

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Fig. 3

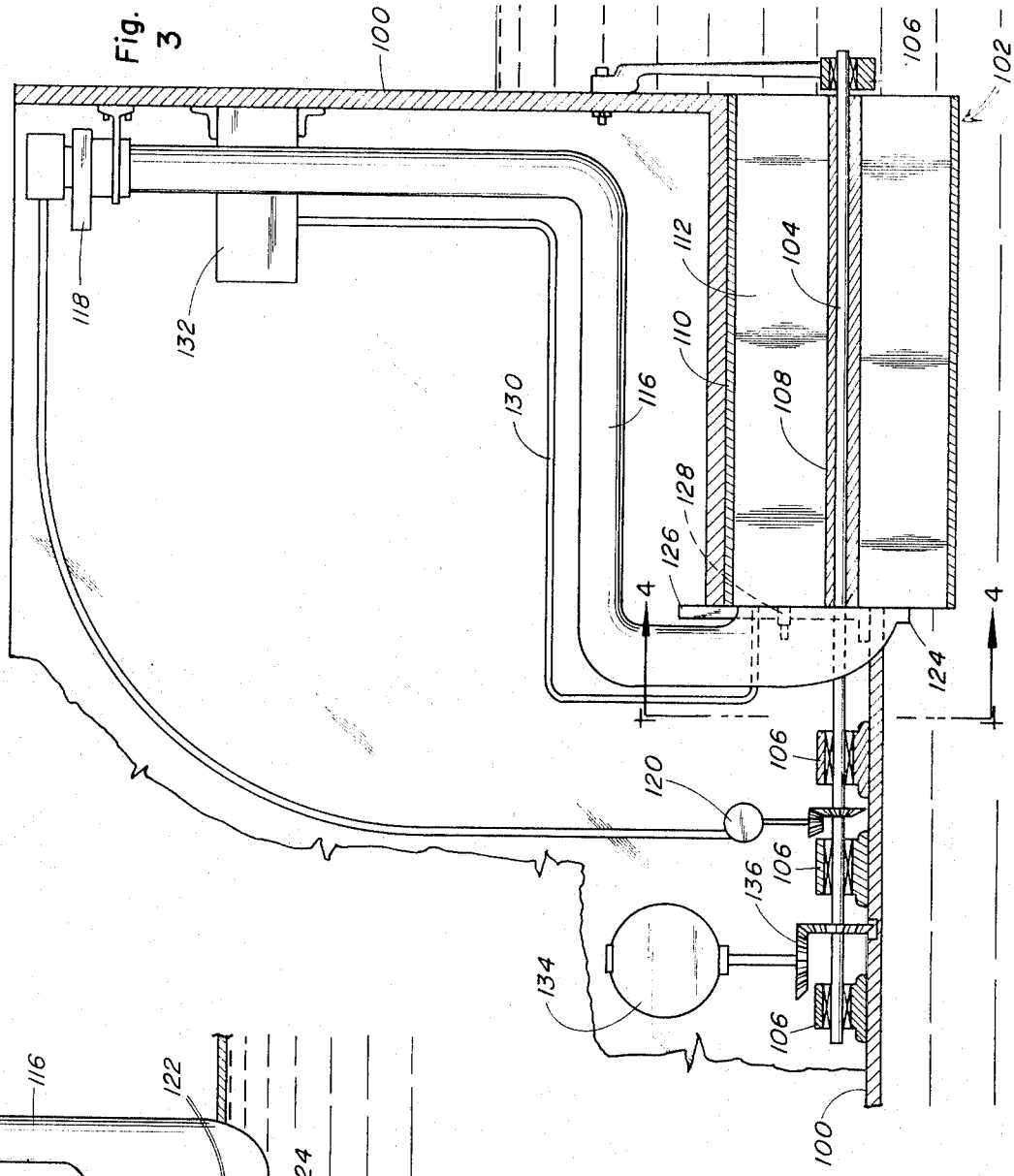
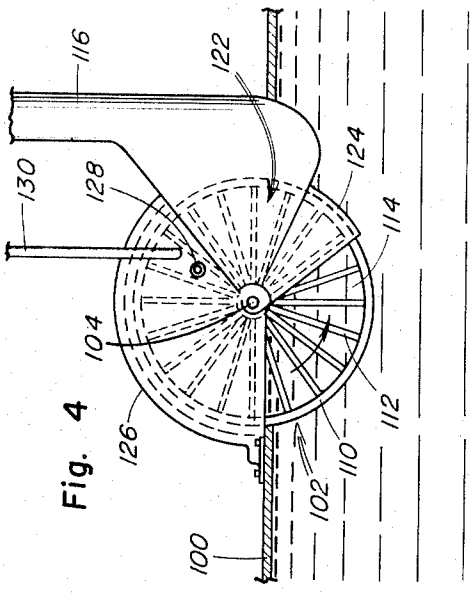


Fig. 4



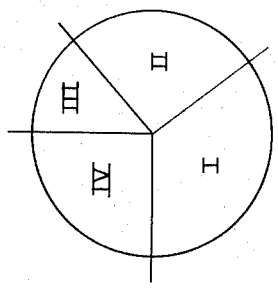


Fig. 4a

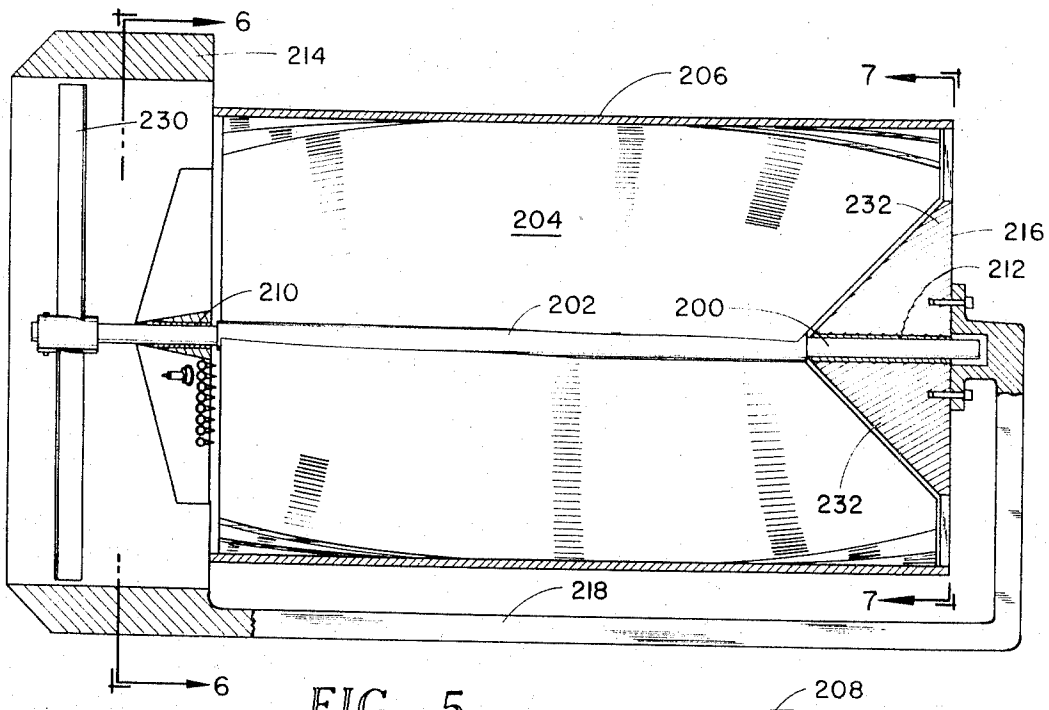


FIG. 5

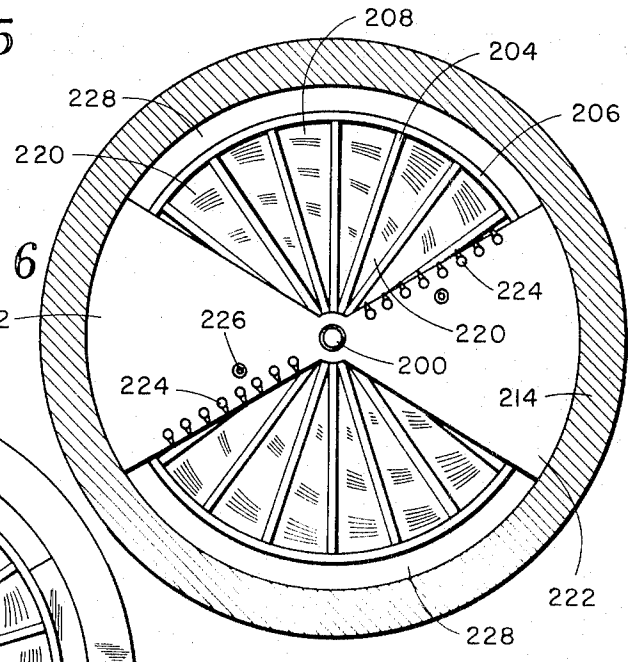


FIG. 6

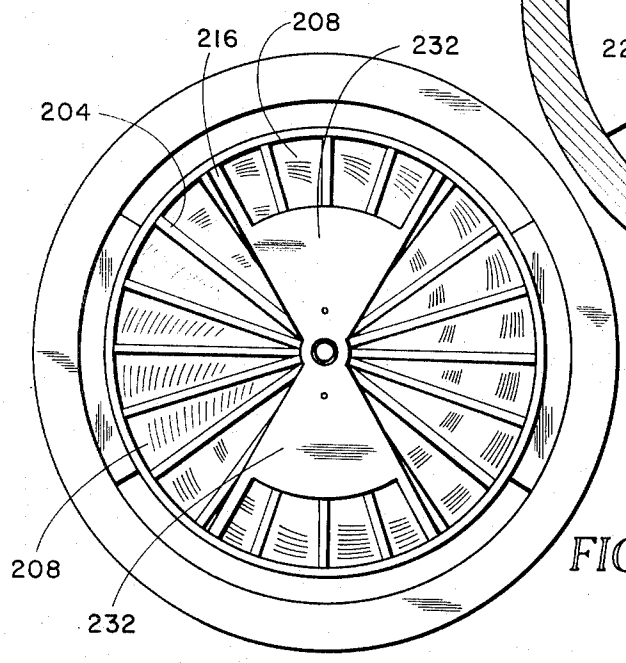


FIG. 7

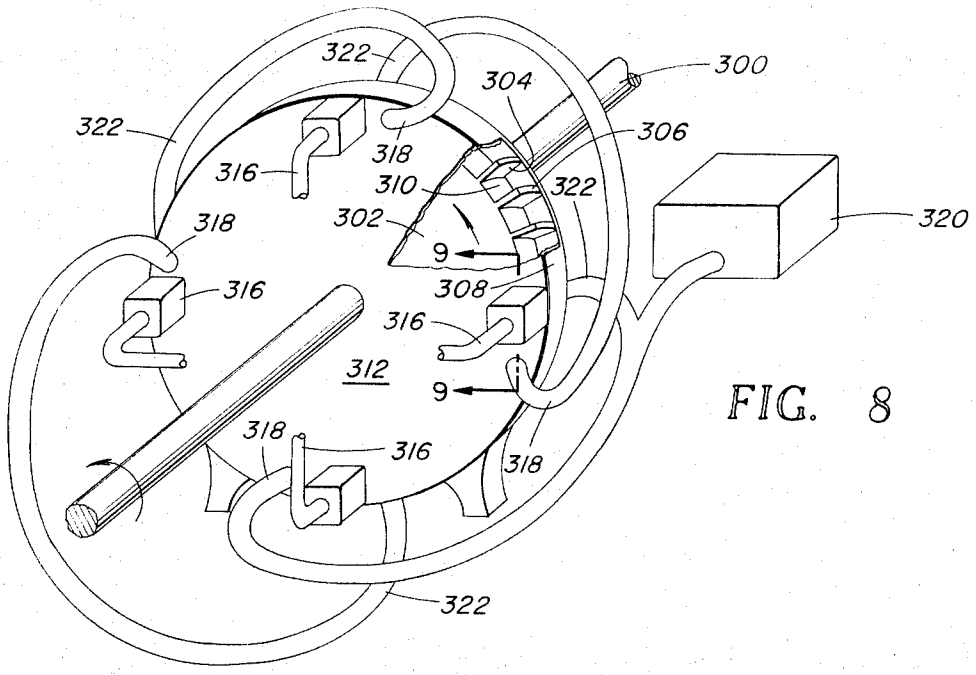

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FIG. 8

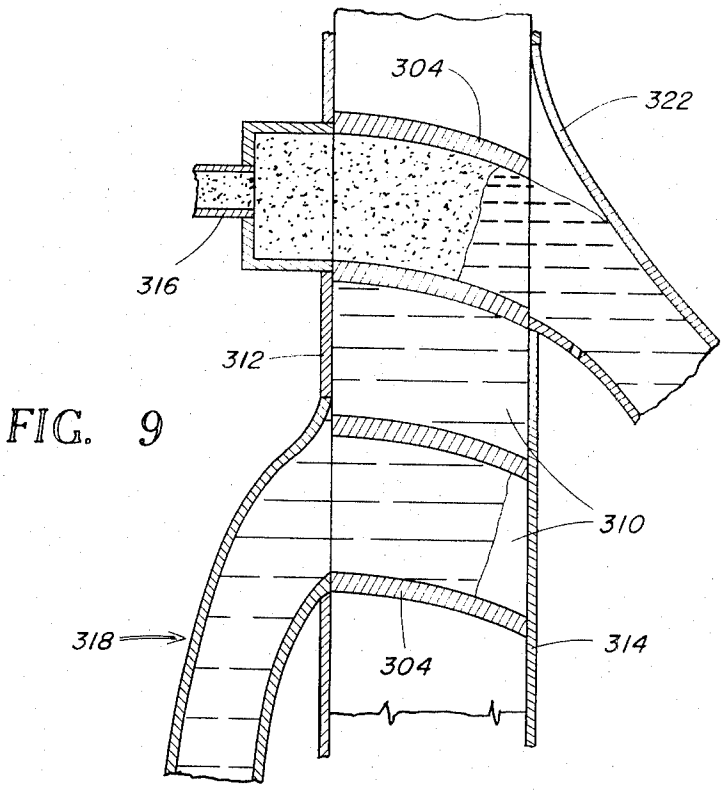

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FIG. 9

THRUST AUGMENTING EXPANSION ENGINE

BACKGROUND OF THE INVENTION

This invention relates generally to an expansion engine and more particularly to a thrust augmenting expansion engine.

There has been a long felt need for a reliable, simple, efficient, compact, low maintenance expansion engine. Expansion engines have been used in the past as prime movers for providing power, and as propulsion systems for underwater, water surface and air vehicles. In each of these embodiments various problems have arisen which heretofore have gone unsolved or have been solved at the expense of creating some other problem less important in that particular application. For example, propeller driven underwater propulsion systems for torpedoes become very inefficient at speeds above seventy knots. Much of the loss occurs because the force between the propeller blades and the water is not parallel to the vehicle velocity. This causes much of the shaft power to be wasted in giving a rotational velocity to the water. Propellers often cavitate at high speeds which causes a drastic drop in propeller efficiency. Much effort has been spent towards developing direct thrust propulsion devices which would avoid the losses mentioned above. A rocket is such a direct thrust device. However, a rocket is inefficient in the above-mentioned applications because of its high exhaust. Therefore, propeller driven underwater vehicles although having a long range must travel at slow speed, while rockets attain high speeds but are only useful for a short range and require a large part of the underwater vehicle's volume for fuel storage. Thus, both propeller and rocket propulsion devices have been found not to be wholly successful for torpedo propulsion.

Both propeller and jet pump propulsion systems have been used in the past for water surface vehicles, but here again each system has its own distinct disadvantages. Propeller driven surface vessels cannot operate in shallow water, since vegetation tends to clog and bind the propellers. Furthermore, propeller driven surface vehicles are very inefficient at high speeds. Prior art jet pumps can be used at high speeds, but heretofore have been burdensomely large, extremely expensive, experience severe maintenance problems and must be manufactured of expensive exotic materials.

Aircraft engines of the propeller, pulse jet, and turbo jet type have all been used in the past, each with some degree of success. Propeller driven aircraft are limited inherently to low speeds, and are mechanically complex thus tending to create severe maintenance problems. Pulse jets are extremely inefficient, and are entirely too large for the amount of thrust developed. Furthermore, pulse jets experience take-off problems due to low initial thrust, and the exotic valving utilized creates severe maintenance problems. Turbo jets, perhaps the most successful, have been found to be extremely expensive because of the exotic materials necessary to cope with the high speeds of rotation and high temperatures.

Radial flow thrust augmenting engines have been proposed, but these devices experience serious centrifugal force and cavitation problems.

SUMMARY OF THE INVENTION

Accordingly, one object of this invention is to provide a new and improved low cost thrust augmenting expansion engine which is compact and efficient.

Another object of the invention is the provision of a new and improved axial flow thrust augmenting expansion engine.

Still another object of the present invention is to provide a new and improved axial flow thrust augmenting expansion engine which utilizes few moving parts to provide a continuous output.

A still further object of this invention is the provision of a new and improved multichannel axial flow expansion engine to propel a long range high speed torpedo.

Another still further object of the instant invention is the provision of a new and improved long range, high speed torpedo which is capable of carrying a large payload.

Still another further object of the instant invention is to provide a new and improved torpedo propulsion system which is capable of long range propulsion at high speed utilizing an axial flow thrust augmentation device.

Still another object of the instant invention is to provide a new and improved water surface vehicle propulsion system which is capable of operation in shallow and/or weed infested waters.

Still another further object of the instant invention is the provision of an efficient low cost water surface ship expansion engine which is capable of weed ingestion.

Still another further object of the instant invention is to provide a new and improved axial flow aircraft expansion engine which has a high efficiency and can be manufactured at a low cost.

Another still further object of the instant invention is the provision of a new and improved thrust augmenting axial flow aircraft expansion engine which is simple in construction and requires little maintenance.

One other object of this invention is the provision of a new and improved turbine which fills the volume between the turbine blades with a fluid prior to introduction of an expandable gas while preventing radial escape of the fluids from the turbine.

Still one other object of this invention is the provision of a new and improved turbine which fills the volume between the turbine blades with a fluid prior to introduction of an expandable gas and subsequently permits the exit momentum of the fluid to be utilized for supplying the turbine with fluid at the inlet portion.

Briefly, in accordance with one embodiment of this invention, these and other objects are attained by providing an expansion engine having a rotatable member with inlet and exit protions supported on an axially extending shaft by an axially extending central hub with a plurality of equally spaced radially extending vanes secured about the periphery thereof at an angle to the shaft and extending from the inlet portion to the exit portion for forming a plurality of equally spaced circumferentially open ended channels. Provision is made for introducing a fluid into the inlet portion of at least one of the channels, and for substantially preventing fluid from escaping radially from all of the channels. Provision is also made for introducing an expandable gas into the inlet portion of at least one of the channels when that channel is filled with the fluid.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and many of the attendant advantages thereof 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:

FIG. 1 is an exploded perspective view of a preferred embodiment of the invention showing the aft end of a torpedo and the propulsion unit therefor;

FIG. 2 is a cut-away perspective view of the thrust augmenting member of the propulsion unit of FIG. 1;

FIG. 3 is a side plan view of a second embodiment of the invention when used as a propulsion system for a water surface ship;

FIG. 4 is a sectional view along the line 4—4 of FIG. 3;

FIG. 4*a* is a schematic representation of the cycle of the expansion engine of FIG. 4;

FIG. 5 is a side view, partially in section of a third embodiment of the present invention in the form of an aircraft engine;

FIG. 6 is a sectional view along the line 6—6 of FIG. 5;

FIG. 7 is a plan view of the aft end of the engine of FIG. 5;

FIG. 8 is a perspective view of a fourth embodiment of the present invention utilized as a turbine; and

FIG. 9 is a sectional view along the line 9—9 of FIG. 8.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings wherein like reference characters designate identical or corresponding parts throughout the several views, and more particularly to FIG. 1 thereof, a first embodiment of the present invention is shown as consisting essentially of a torpedo propulsion system mounted on the aft end of a torpedo body **10** having an axial shaft **12** affixed to and extending from the aft end of the torpedo body. A structure-conically shaped rotatable thrust augmenting or thrustor member **14** is fixedly mounted on shaft **12** in abutting relationship with the rear surface **16** of the torpedo body **10.** The rotatable thrustor **14** consists essentially of a central axial hub **18** and a concentric shroud **20** interconnected by a number of axially extending evenly spaced helical vanes **22,** thus forming a plurality of equally spaced open ended peripheral channels **24.** As can be clearly seen in FIGS. **1** and **2** the shroud **20** prevents fluid from escaping radially from the channels **24** while allowing fluid to freely pass through the open ends of the channels. When in the assembled position, the thrustor member **14** is held in positin on shaft **12** by a securing member **26** releasably attached to end **28** by conventional means such as screw threads, thus orienting the rotatable member **14** to have an inlet portion **30** adjacent surface **16** of the torpedo body **10** and an exit portion **32** at the rear thereof.

The aft end of torpedo body **10** is shaped to provide water channels **34** by reducing the outside diameter of the aft end of the torpedo to be equivalent to the outside diameter of the hub **18** such that water may freely pass into the channels **24** as the torpedo is propelled. The diameter of the torpedo between the water channels **34,** at extended portions **36,** is substantially equivalent to the abutting diameter of the shroud **20.** Assuming the thrustor member **14** is rotating clockwise when viewed from the aft end of the torpedo, a plurality of diametrically spaced gas ports **38** are provided adjacent the leading edges **40** of the extended portions **36** in the aft end of the torpedo. In operation, water sequentially enters the helically shaped channels **24** when aligned with water channels **34.** The channels **24** are thus filled with water by the time they reach the edges **40** of the extended portion **36.** The gas ports **38** become aligned with the front opening of the channel immediately after the front opening is completely blocked by the extended portion **36.** The gas ports **38** then admit high pressure gas to the channels. The particular source of high pressure gas is not part of the present invention and any conventional source of high pressure gas utilized in a torpedo may be used with this propulsion system. The high pressure gas accelerates the already moving water in the channels **24** toward the rear or exit portion **32.** The volume within channels **24** available to the gas increases as the water moves to the rear but the gas pressure remains nearly constant while the front opening is aligned with the gas port **38.** The inlet portion **30** of the channel remains blocked by the extended portion **36** for a time after passing the gas port. The high pressure gas in each channel continues to accelerate the water to the rear, and the gas pressure decreases as the volume increases. The cycle ends, and a new cycle starts, when the front opening of the channel passes thr extended portion **36** and is exposed to the next water channel **34** for filling with water again. At this time the gas pressure will have dropped to about the ambient pressure, and the water will be completely expelled. The thrust transmitted to the propelled vehicle is the force on the extended portions **36** of the aft end of the torpedo body **10** by the high pressure gas. The reaction force is the force on the water being accelerated to the rear. The rotatable member **14** may be in the shape of a frustrum of a cone as shown in FIGS. **1** and **2** or the thrustor **14** may be cylindrical. The slight change in shape of the rotatable member **14** will not substantially alter the opening characteristics of the propulsion system.

The embodiment of the invention illustrated in FIGS. **3, 4** and **4a** consists of the expansion engine utilized as a propulsion system for a water surface vehicle **100.** In this embodiment, a thrust augmenting or thrustor member **102** is fixedly secured to a shaft **104** which in turn is mounted for rotation in bearings **106** on the water surface vehicle. The thrustor **102** is basically the same as the thrustor member **14** of FIG. **1.**

The thrustor consists of a hub **108** and a concentric shroud **110** interconnected by a number of axially extending evenly spaced helical vanes **112** defining a plurality of open ended axially extending helical channels **114** symmetrically arranged about the shaft **104.** As can be seen more clearly in FIG. **4,** a portion of the thrustor **102** is exposed to an influx of water to the channels **114.** A fuel air mixture is introduced sequentially into the water filled channels by means of conduit **116** from a conventional carburetor **118,** which in turn, may be fed with air under pressure by means of a blower **120** driven by shaft **104.** The conduit **116** is shaped so as to have an opening abutting the inlet section of a number of channels **114** when the channels are filled with water.

Extending from the edge of the open end portion **122** of conduit **116** is a plate-like member **124** which seals off the forward portion of at least one channel prior to that channel becoming aligned with the open end **122** of conduit **116.** A closure plate **126** abuts the inlet portion of thrustor **102** to seal off the inlet portions of channels **114** after the fuel-air mixture has been introduced into the channels. A conventional ignition device such as a spark plug **128** is provided within the plate **126** for igniting the fuel-air mixture within the channels as they rotate into alignment therewith.

A tube **130** terminating adjacent ignition device **128** and extending through plate **126** may be provided for introducing a fuel other than the fuel-air mixture into the channels from a storage tank **132** to either supplement the fuel-air mixture provided through conduit **116** or to be used alone.

In order to vary the thrust of the expansion engine the end **122** of conduit **116** and integral plate **124** may be mounted for rotation about shaft **104** to slidingly rotate over plate **126,** thus varying the size of the opening through which the fuel-air mixture enters into the channels **114.** A conventional starter motor **134** and associated gearing **136** may be further provided for initiating rotation of shaft **104** and thus starting the engine into operation.

Referring specifically to FIG. *4a* when viewed with FIG. **4,** it can be seen that segment I represents the water intake and gas exhaust cycle, segment II represents the fuel-air mixture intake cycle, segment III represents the fuel-air mixture ignition cycle and segment IV represents the gas expansion and water exhaust cycle of the expansion engine.

Another embodiment of the expansion engine of the present invention particularly suitable for application as a propulsion system for an aircraft is illustrated in FIGS. **5, 6** and **7.** In this embodiment, a shaft **200,** hub **202,** helically extending vanes **204** and concentric shroud **206** are assembled as a unit to define a plurality of open ended symmetrically arranged helically extending channels **208.** The shaft **200** is mounted for rotation within bearings **210** and **212** mounted on fixed members **214** and **216** each of which is fixed to a mount **218.** Inlet member **214** is shaped so as to provide open sections **220** and air blocking sections **222.** Assuming the vanes **204** to be rotating in a clock-wise direction as viewed in FIG. **6** it can be seen that each channel **208** is filled with air when in alignment with open sections **220.** When in this position fuel is sprayed across the open faces of channels **208** by nozzles **224** mounted on the leading edges of blocking members **222** and the thrust of the engine may be controlled by varying the nozzle pressure so as to cover a larger or smaller number of channels with fuel. As the channels pass into alignment with air blocking sections **222** the fuel is ignited by means such as sprak plugs **226.** Air overflow passages **228** are provided in the inlet member **214** for allowing cooling air to pass about the rotating shroud **206.** A single stage compressor **230** may be mounted on shaft **200** for rotation therewith thus providing air under pressure to the inlet of channels **208.** Exit member **216** consists essentially of constricting members **232** for restricting the exit fluid flow from those channels containing expanding gases to convert the pressure head to a velocity head in a manner similar to a conventional convergent nozzle.

In the turbine application embodiment of the present invention illustrated in FIGS. **8** and **9,** a shaft **300** is mounted fr rotation within bearings (not shown) so as to mount a substantially disc shaped member **302** for rotation therewith. Equally spaced about the periphery of disc **302** are a plurality of radially extending curved blades **304.** Secured to the outer edges **306** of blades **304** is a band shaped shroud **308** enclosing the outer radial edges of the blades for defining a plurality of open ended channels **310** about the periphery of the disc shaped member **302.** Stationary circular cover plates **312** and **314** are mounted adjacent to the respective flat surfaces of disc **302** to enclose the ends of channels **310.** Inlets are provided through cover plate **312** as shown generally at **316** for sequentially introducing an expandable gas such as steam into the channels **310.** Prior to introduction of steam through inlet **316** a fluid such as water is introduced into the channels by way of conduits **318** through cover **312.** A reservoir **320** is provided to maintain a sufficient amount of water within the conduits **318** to efficiently fill the channels **310.** Thus it can be seen that water fills the channels **310** by means of conduits **318,** and as the conduits pass before steam inlets **316** the expanding steam forces the water out of the conduit **310** into an exit portion **322** of conduit **318.** The conduit **318** is provided to take advantage of the momentum of the exiting fluid from the channels **310.** The exit fluid from a channel **310** when in alignment with steam inlet **316** can thus be utilized to reenter the system through cover plate **312,** thus imparting its momentum to blades **304.** It is not necessary that conduits **318** be entirely enclosed but could rather be open chutes merely directing the exit fluid from cover plate **314** back to cover plate **312.**

It will be apparent from the foregoing disclosure that each of the various embodiments operates on the same basic principle of thrust augmentation wherein power from a high pressure gas being isentropically expanded to ambient pressure may be imparted to a slug of fluid thus increasing the overall thrust of the system.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. An expansion engine for a torpedo body having a forward portion and a planar aft end comprising a shaft secured to and extending axially from the aft end of said torpedo body,

a rotatable member having an inlet portion and an exit portion,

said rotatable member further having an axially extending central hub rotatably supported on said shaft such that the inlet portion is in abutting relation with said planar aft end of said torpedo body,

a plurality of equally spaced radially extending vanes secured about the periphery of said hub at an angle with the axis of said shaft and extending from said inlet portion to said exit portion for forming a plurality of equally circumferentially spaced open ended channels,

said aft end of said torpedo body having an outside diameter substantially equivalent to the outside diameter of said channels,

said aft end having at least one section of reduced diameter substantially equivalent to the inside diameter of said channels,

means for introducing a fluid into the inlet portion of at least one of said channels,

means for substantially preventing fluid from escaping radially from said channels, and

means for introducing an expandable gas into the inlet portion of at least one of said channels when said channel is filled with said fluid.

2. An expansion engine according to claim **1** wherein said means for introducing an expandable gas into the inlet portion of at least one of said channels is at least one gas port in said aft end of said torpedo body in axial alignment with said channels in said rotatable member.

3. An expansion engine according to claim **2** wherein a plurality of symmetrically arranged sections of reduced diameter are provided on the aft end of said torpedo body each of which is substantially equivalent in diameter to the inside diameter of said channels, and a plurality of said ports, equal in number to said sections of reduced diameter, are provided in said aft end of said torpedo body in axial alignment with said channels in said rotatable member.

4. An expansion engine according to claim **3** wherein siad channels are decreasing in cross section from said inlet portion to said exit portion of said rotatable member.

5. An expansion engine according to claim **3** wherein said central hub, said vanes and said means for substantially preventing fluid from escaping radially from said channels are constructed as a single unit so as to rotate together about said shaft.

6. An expansion engine comprising an axially extending shaft,

a rotatable member having an inlet portion and an exit portion,

said rotatable member having an axially extending central hub supported on said shaft for rotation therewith,

a plurality of equally spaced radially extending vanes secured about the periphery of said hub at an angle with the axis of said shaft and extending from said inlet portion to said exit portion for forming a plurality of equally circumferentially spaced open ended channels,

means for introducing a fluid into the inlet portion of at least one of said channels,

means for substantially preventing fluid from escaping radially from said channels,

means for introducing an expandable gas into the inlet portion of at least one of said channels when said channel is filled with said fluid, and

means for rotating said shaft for starting said engine.

7. An expansion engine according to claim **6** wherein said engine is mounted at the aft end of a water surface vessel, and

at least a portion of said inlet portion of said channels being exposed to direct influx of water below said water surface vessel.

8. An expansion engine according to claim **7** wherein said means for introducing an expandable gas into the inlet portion of said channel comprises a carburetor,

a conduit extending from said carburetor to the inlet portion of said channel for providing a fuel-air mixture to said channel when filled with water, and

means for igniting said fuel-air mixture.

9. An expansion engine according to claim **8** further comprising

means for providing air under pressure to said carburetor, means for preventing said expandable gases from escaping through the inlet portion of said rotatable member.

10. An expansion engine according to claim **9** further comprising means for varying the thrust of said engine.

11. An expansion engine according to claim **10** further comprising

means for providing a second source of expandable gas to said channel in alignment with said ignition means.

12. An expansion engine for an aircraft comprising an axially extending shaft,

a rotatable member having an inlet portion and an exit portion,

said rotatable member having an axially extending central hub supported on said shaft,

a plurality of equally spaced radially extending vanes secured about the periphery of said hub at an angle with the axis of said shaft and extending from said inlet portion to said exit portion for forming a plurality of equally circumferentially spaced open ended channels,

means for introducing air under pressure into the inlet portion of at least one of said channels,

means for substantially preventing air from escaping radially from said channels,

a plurality of fuel nozzles directed into said channels through said inlet portion for introducing fuel into the inlet portion of at least one of said channels when said channel is filled with air.

13. An expansion engine according to claim **12** further comprising means for varying the thrust of said engine.

14. An expansion engine according to claim **13** wherein said air introducing means comprises an air compressor rotatably mounted on said shaft forward of said inlet portion.

15. An expansion engine according to claim **14** further comprising means for allowing a portion of said air to bypass said rotatable member.

16. An expansion engine according to claim **15** further comprising means at the exit portion of said rotatable member for partially restricting fluid flow from said channels.

17. An expansion engine comprising an axially extending shaft,

a rotatable member having an inlet portion and an exit portion,

said rotatable member having an axially extending central hub supported on said shaft,

a plurality of equally spaced radially extending vanes secured about the periphery of said hub at an angle with the axis of said shaft and extending from said inlet portion to said exit portion for forming a plurality of equally circumferentially spaced open ended channels,

means for introducing a fluid into the inlet portion of at least one of said channels,

means for substantially preventing fluid from escaping radially from said channels,

means for introducing an expandable gas into the inlet portion of at least one of said channels when said channel is filled with said fluid, and

conduit means communicating with and extending from said exit portion of at least one channel to the inlet portion of at least one preceding channel in the direction of rotation.

18. An expansion engine according to claim 17 wherein said rotatable member is affixed to said shaft, and further comprising means for extracting power from said shaft.

19. In combination with an underwater vehicle, a propulsion system comprising:

a shaft secured to and extending from the aft end of said vehicle,

an axially extending central hub mounted for rotation on said shaft in abutting relationship with said aft end of said vehicle,

radial vanes secured to said hub and helically extending about the axis of said shaft,

a shroud secured to said vanes to form a plurality of axially extending open ended helical channels symmetrically arranged about the peripheral extent of said hub,

said aft end of said vehicle being so shaped as to permit water to enter only a portion of said helical channels, and

means on said aft end of said vehicle for rotating said hub.

20. The device of claim 19 wherein a portion of said aft end of said vehicle has an outside diameter substantially equivalent to the outside diameter of said channels, and at least one segment of said aft end of said vehicle has an outside diameter substantially equivalent to the inside diameter of said channels.

21. The device of claim 20 wherein said means for rotating said thrust augmenting member comprises at least one source of gas in said vehicle and a port in the aft end of said vehicle at the portion of maximum diameter for releasing said gas into said channels when filled with water.

22. The device of claim 21 wherein said channels are convergent in cross section.

23. An aircraft engine comprising a shaft rotatably mounted on said aircraft parallel to the axis of said aircraft,

a cylindrical thrust augmenting member mounted on said shaft and having a plurality of open ended channels symmetrically arranged about said shaft, said channels helically extending about the axis of said shaft,

means for blocking air from entering at least one segment of the forward end of said cylindrical member,

means on said blocking means for introducing fuel into the forward open end of said cylindrical member,

means on said blocking means for igniting said fuel,

means on said shaft forward of said blocking means for providing air under pressure to the forward open ends of said channels, and

bypass means for allowing a portion of said air under pressure to flow around the outer surface of said cylindrical member.

24. The aircraft engine of claim 23 further comprising means for restricting exit fluid flow through at least one segment of said cylindrical member.

25. An engine comprising a rotatably mounted shaft,

a substantially disc-shaped member affixed to said shaft and having a plurality of equally spaced radially extending curved blades affixed to the periphery thereof,

means enclosing the outer radial edges of said blades for defining a plurality of open ended channels about the periphery of said disc-shaped member,

first and second cover plates for enclosing said ends of said channels,

means for introducing a fluid through said first cover plate into a selected number of said channels,

means for introducing an expandable gas through said first cover plate into a selected number of said channels when filled with said fluid, and

means for permitting said fluid to escape from said channels through said second cover plate while said expandable gas is being introduced into said channels.

26. The engine of claim 25 further comprising means for guiding said escaping fluid from said second cover plate to said first cover plate to pass therethrough into said channels.

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