US 20110004993A1

(19) **United States**

(12) **Patent Application Publication**

Frei

(10) **Pub. No.: US 2011/0004993 A1**

(43) **Pub. Date: Jan. 13, 2011**

(54) **SWIMMING POOL WITH EDUCTOR JETS**

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(21) Appl. No.: **12/923,232**

(22) Filed: **Sep. 10, 2010**

Related U.S. Application Data

(63) Continuation-in-part of application No. 11/896,998, filed on Sep. 7, 2007.

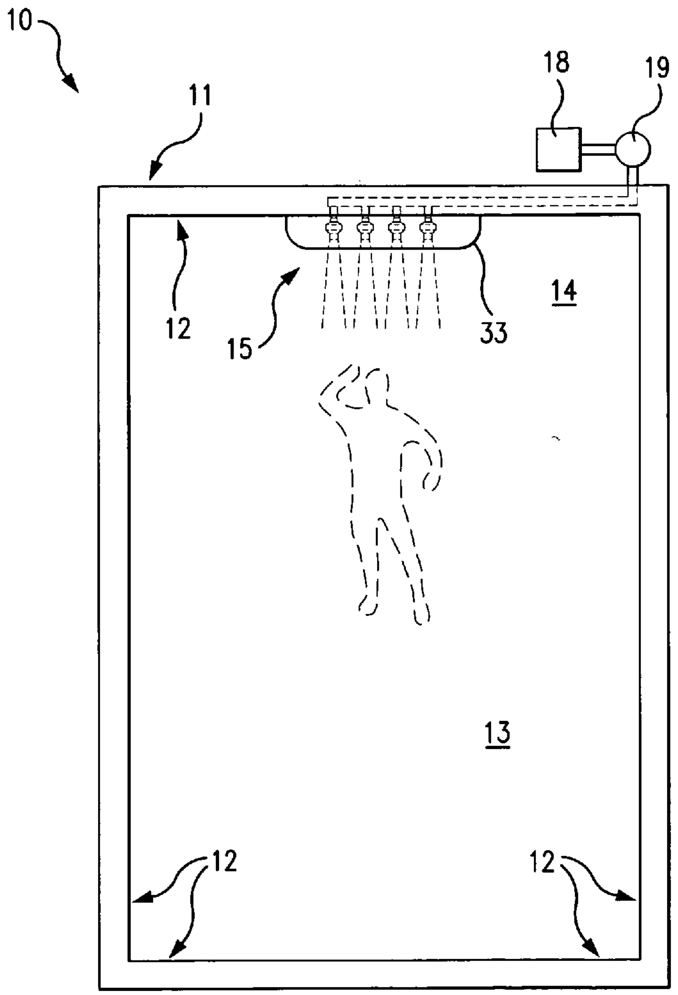
Publication Classification

(51) **Int. Cl.**
E04H 4/12 (2006.01)

(52) **U.S. Cl.** **4/492**

(57) **ABSTRACT**

A swimming pool designed for stationary swimming uses Venturi-based eductor jets to generate a forceful water flow augmented by entrained pool water drawn from within the pool enclosure. The eductor jets use the kinetic energy of the inlet flow to entrain the low-pressure pool water, completely mix the two, and then discharge the mixture as an augmented outlet flow. The energy from the motive inlet flow is transferred to the entrained pool water via the Venturi effect. As the motive inlet water passes through a tapered nozzle in the eductor jet, kinetic energy increases and pressure decreases. This produces a Venturi effect which draws surrounding pool water into the Venturi orifice of the eductor jet. Consequently, the volume of the outlet flow from the eductor jets is 3 to 5 times the volume of the inlet flow. A larger and more powerful stream of water is thereby discharged into the pool enclosure and provides optimal resistance for in-place swimming in an energy-efficient manner.



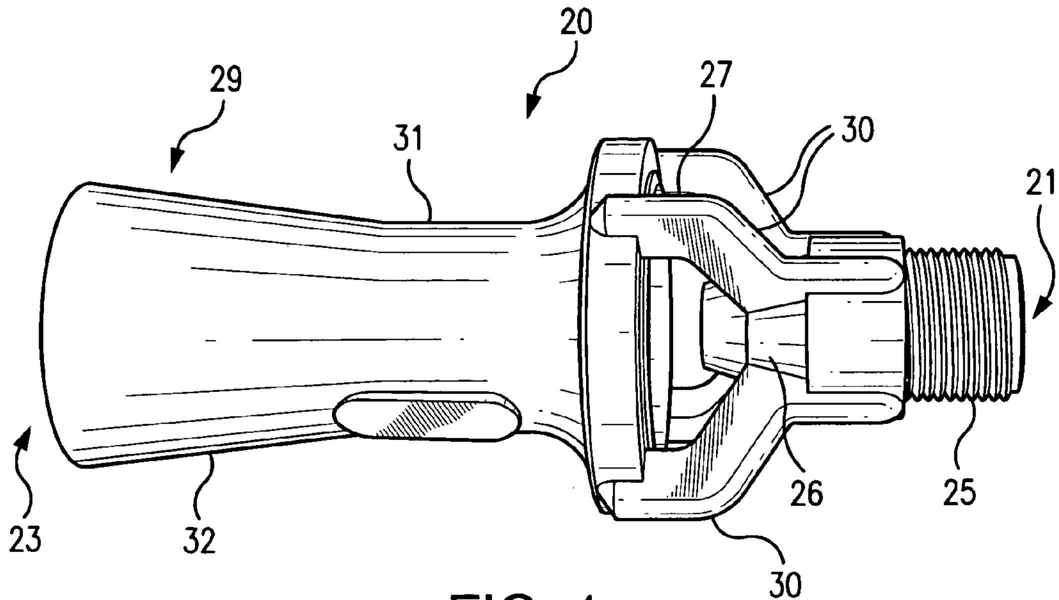


FIG. 1

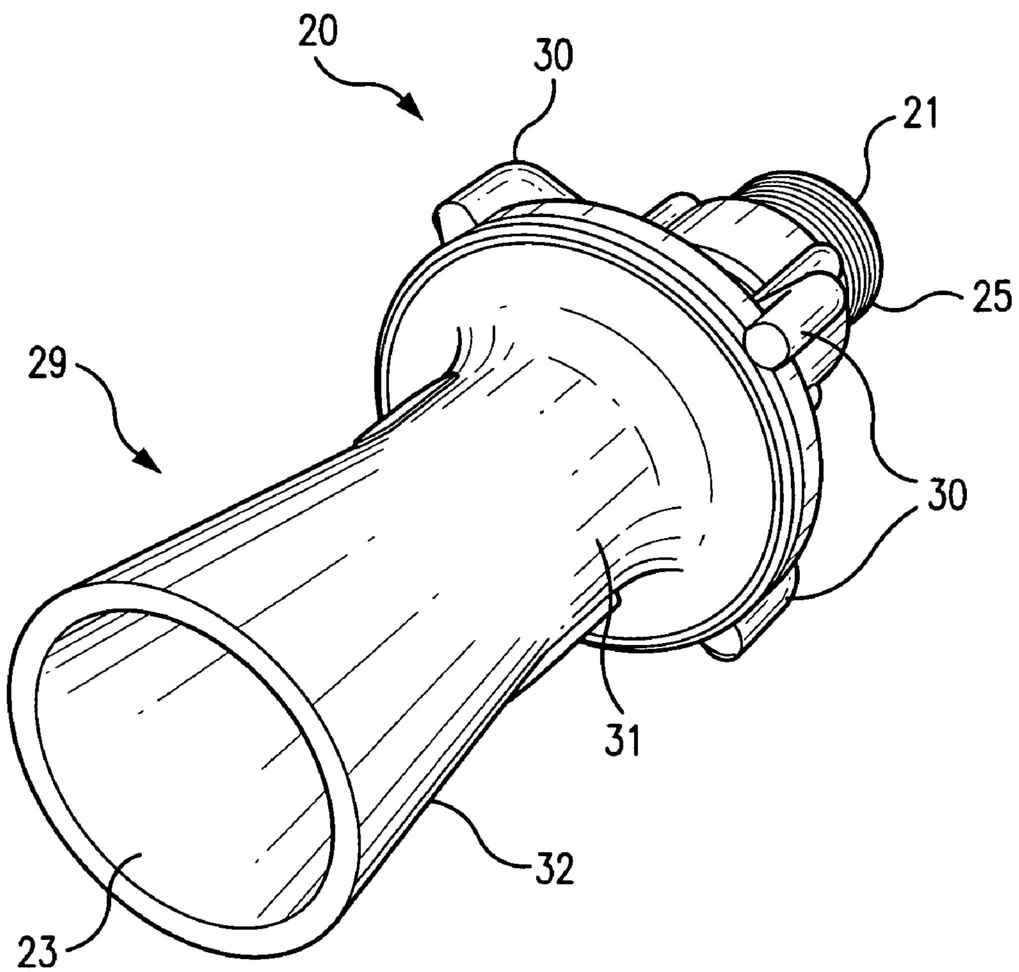


FIG. 2

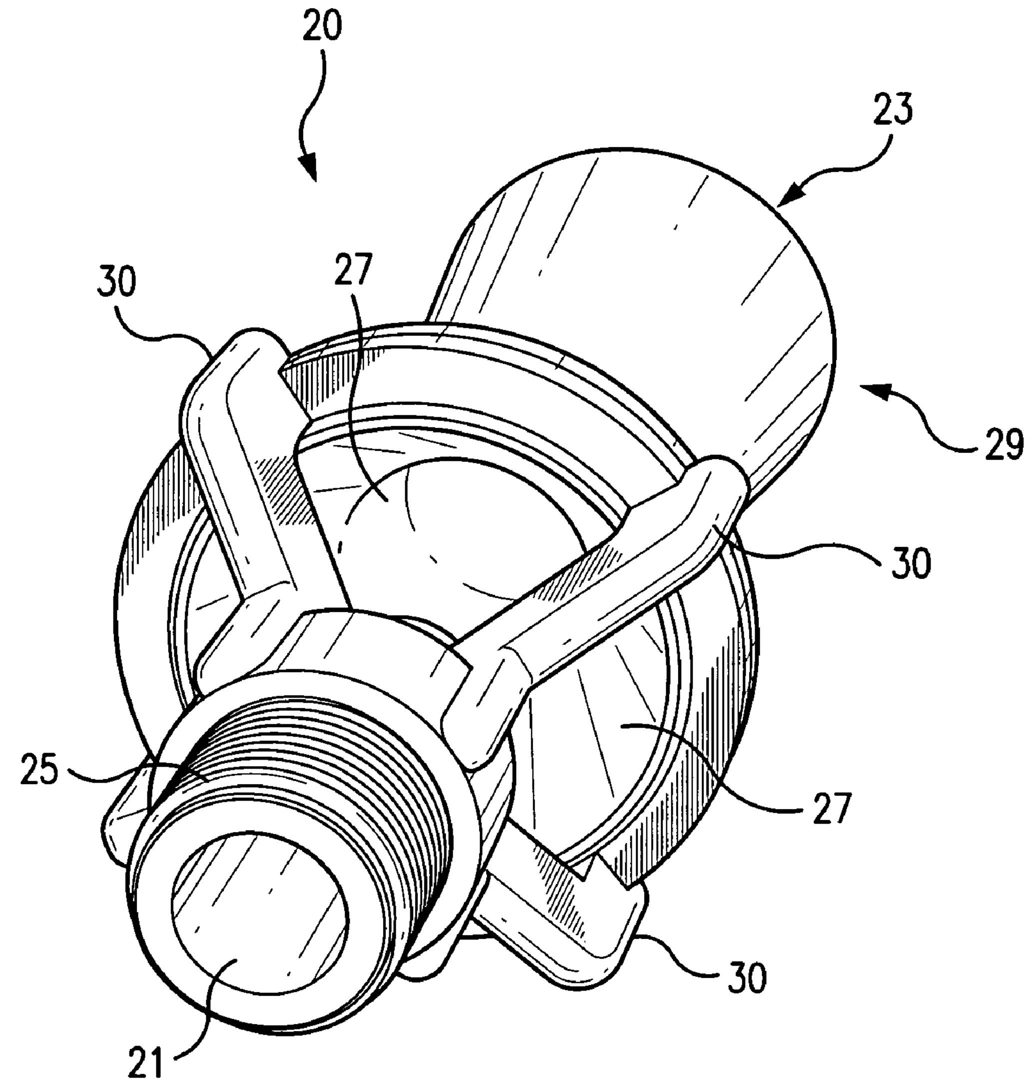


FIG. 3

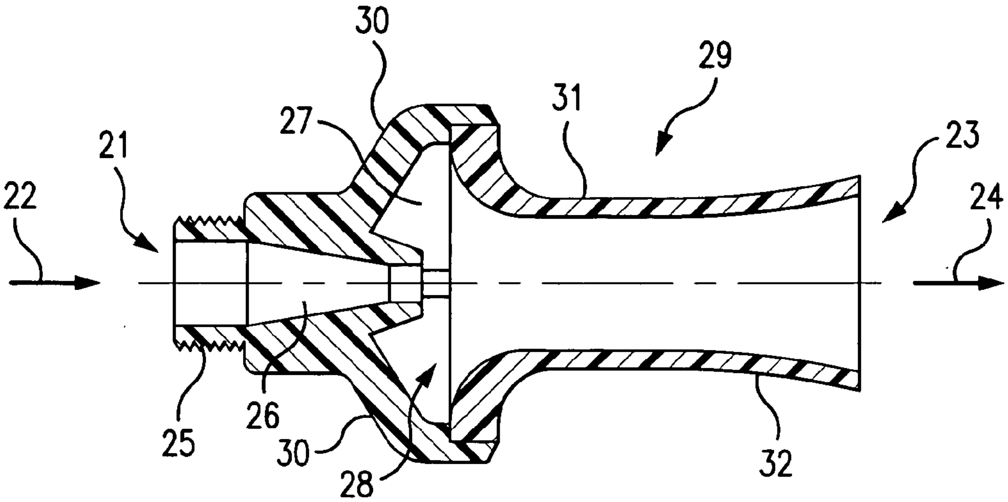


FIG. 4A

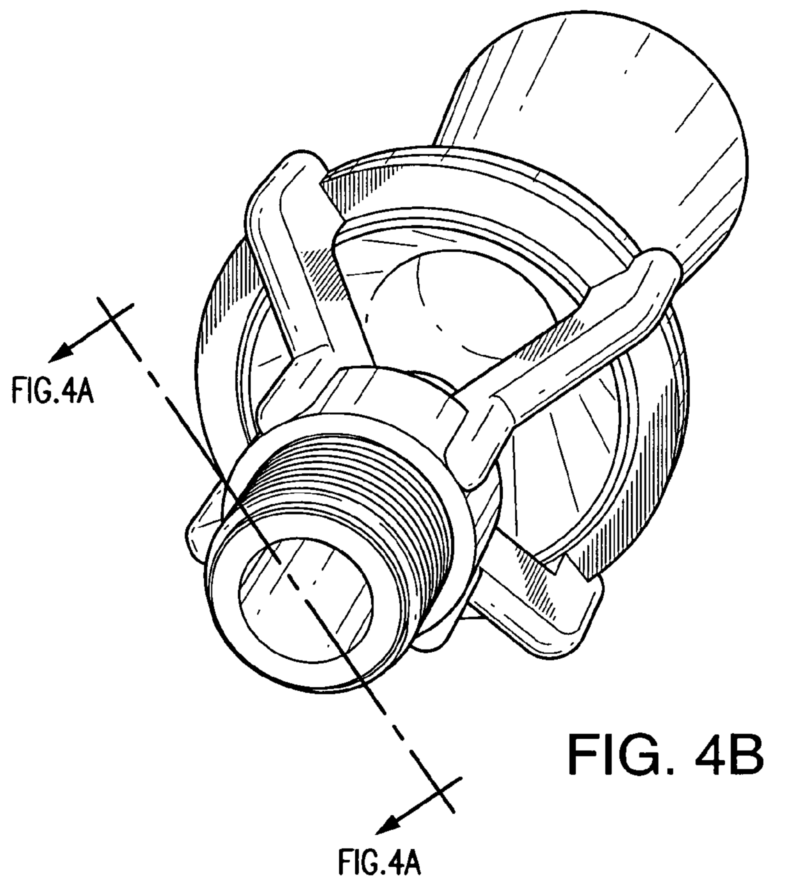


FIG. 4B

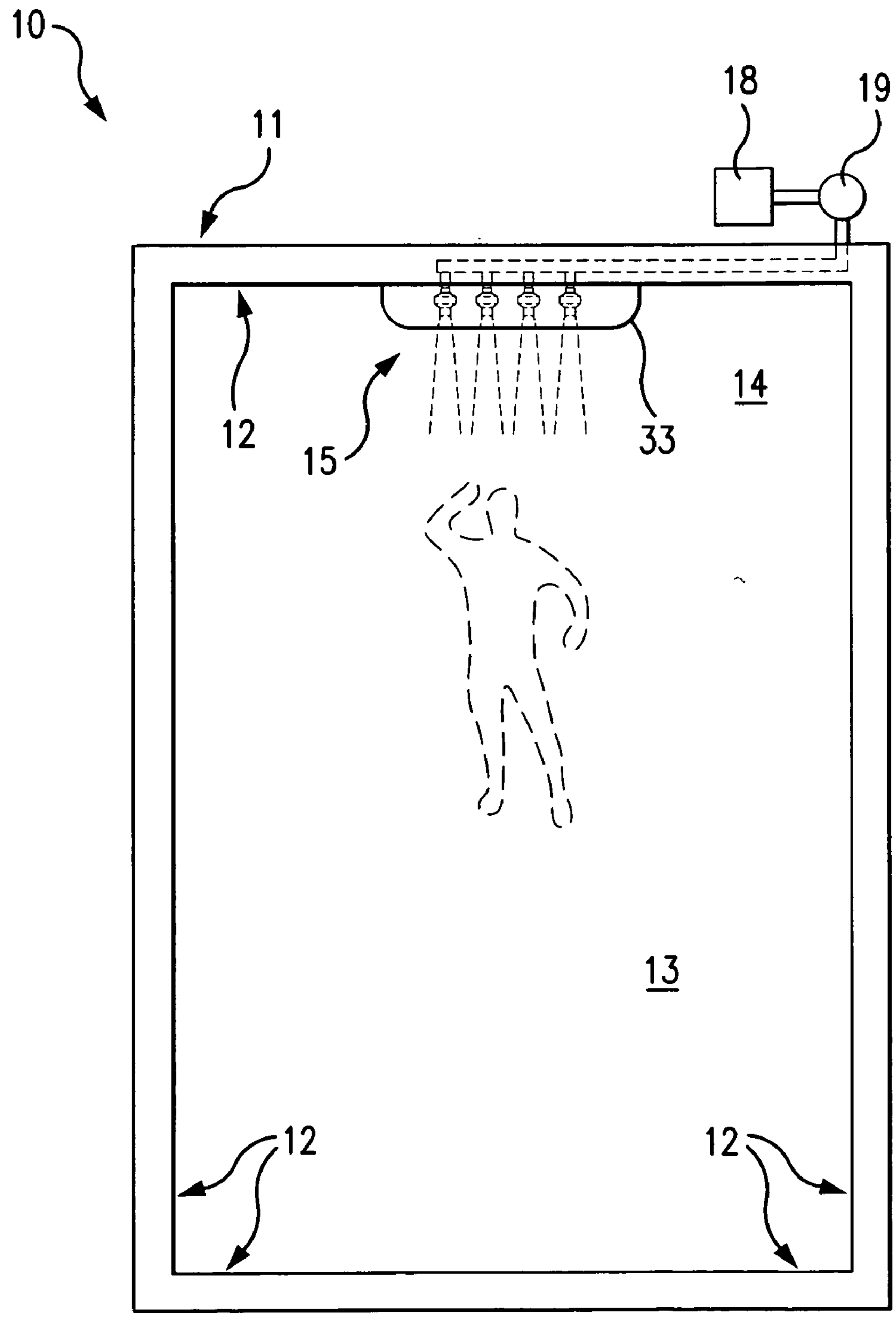


FIG. 5

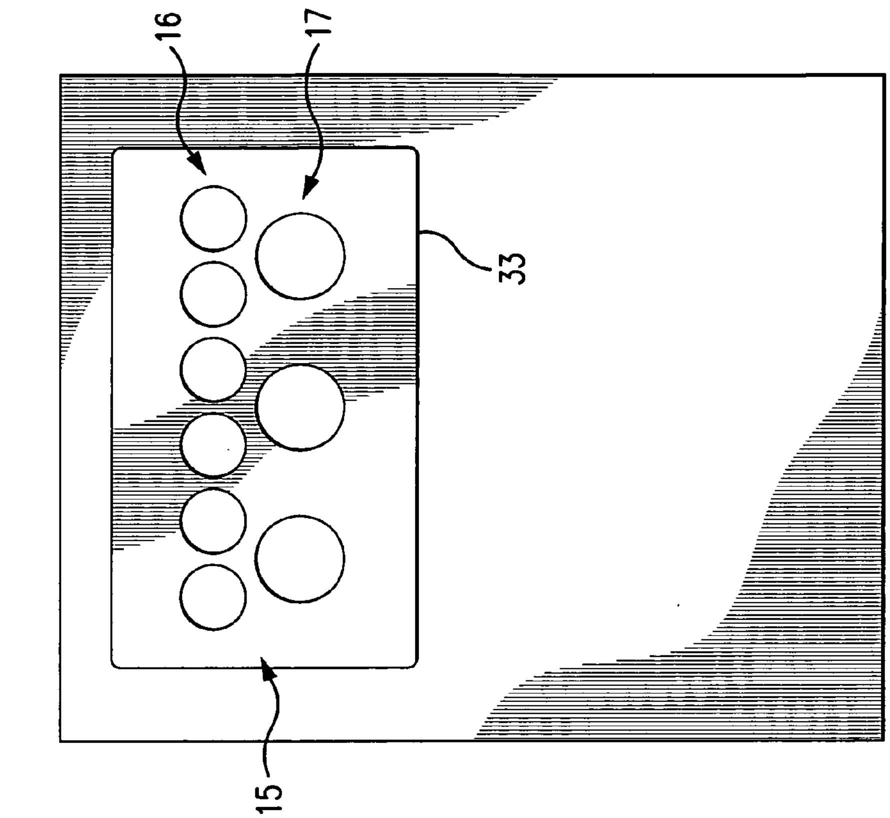


FIG. 7

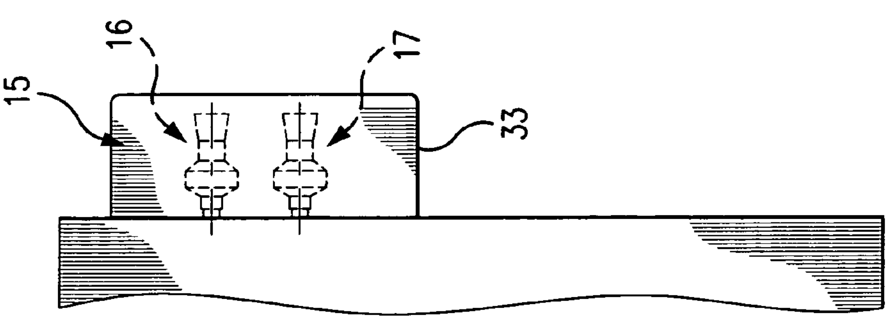


FIG. 6

SWIMMING POOL WITH EDUCTOR JETS

REFERENCE TO RELATED PATENT APPLICATIONS

[0001] This application is a continuation-in-part of application Ser. No. 11/896,998, filed Sep. 7, 2007, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to swimming pools, and more particularly to swimming pools which generate a directed flow of water within the pool enclosure so as to create a current against which a swimmer can swim while remaining stationary.

[0003] In a conventional swimming pool, a swimmer must swim back and forth from one end of the pool to the other. This requires that the pool be rather large, since in a small, short pool the swimmer will continually be turning around and interrupting their swimming stroke, thus making sustained swimming for exercise or recreation impractical. But large pools have several disadvantages. They are expensive to build and maintain, and they occupy a lot of space, which may not be available or may be put to other better uses. Because they contain a large volume of water, they are not energy-efficient, since great amounts of energy are consumed in heating, pumping and filtering the pool water.

[0004] The alternative to a large pool is a smaller pool equipped with water jets to generate a current against which a person can swim in place. The footprint of such jet-equipped swimming pools can be much smaller, while still enabling a person to swim for extended periods of time without turning around. The smaller footprint of a jet-equipped pool allows such pools to be located in more confined spaces, whether indoors or outdoors. But in order for a jet-equipped pool to be energy efficient, the energy expended in powering the jets must be offset by the energy savings resulting from the lower volume of water.

[0005] A swimming pool that uses water jets to create resistance for stationary swimming is disclosed in the patent to Mathis, "Combined Swimming and Therapy Pool", U.S. Pat. No. 4,001,899 (hereinafter referred to as "Mathis 2"). The water jets of Mathis 2 are described in the specification (column 1, lines 28-30; column 2, lines 25-28) and depicted in FIG. **1** (reference no. **14**) as propelling water into the pool enclosure from an external source, which is described as "a conventional source under pressure" (column 3, lines 15-17). Claim 1 of Mathis 2 likewise states (column 3, line 28 through column 4, line 2) that the jet outlets simply move water into the pool enclosure from an external source. Consequently, the volume of water flow expelled by the Mathis 1 jets into the pool enclosure is limited by maximum flow rate of the external "conventional source under pressure", which would typically be the public water line or a private well pump. Moreover, the pressure of water drawn solely from conventional external sources will drop as the volume flow increases. Both of these factors will limit the effective swimming resistance produced by the Mathis 2 jets.

[0006] The specification of Mathis 2 (column 2, lines 23-25) also indicates that the water jets are of the type taught by the same inventor's previous patent, "Whirlpool Jet for Bathtubs", U.S. Pat. No. 3,890,655 (hereinafter referred to as "Mathis 1"). The specification of Mathis 1 (column 2, lines 12-19; column 3, lines 17-26) describes a whirlpool jet in which the water flow through an interior chamber (FIG. **2**, reference no. **14**) is mixed with air drawn into the chamber through a Venturi air inlet (FIG. **2**, reference no. **15**). Claim 1 of Mathis 1 likewise states (column 4, lines 14-19) that the Venturi effect of the pressurized water flow through the chamber draws air in through the Venturi air inlet.

[0007] The type of jet described in Mathis 1 produces the rapid, turbulent, rolling water flow characteristic of whirlpool baths. For this reason, it is suitable in the application of Mathis 2, which is a combined swimming and therapy pool, where the jets expel water directly against the bodies of persons seated in the therapy area (column 2, lines 46-50). While the outflow produced by a Venturi air whirlpool jet has a messaging effect that is appropriate for such therapeutic purposes, it is not optimal for stationary resistance swimming. The air drawn in through the whirlpool jet Venturi inlet, while accelerating the flow of air-water mixture through the jet, cannot augment either the water volume flow rate or the water pressure. Moreover, to the extent the whirlpool jet produces a turbulent outlet flow, it causes the total energy of the outlet stream to be diminished, because turbulence results in much greater internal energy losses as compared with laminar flow. Since the energy dissipated by the whirlpool jet's turbulence is not available to provide flow resistance against the body of a swimmer, such jets are not optimal for in-place swimming applications.

[0008] Furthermore, the air entrained with the water by a whirlpool jet is released as large bubbles at the water surface after being expelled from the jet. In a stationary swimming application, therefore, whirlpool jets will create the irritating distraction of large air bubbles bursting against the swimmer's face.

[0009] The present invention, on the other hand, uses an educator jet, which quite different type from the whirlpool jet taught by the Mathis inventions. Instead of using the kinetic energy of the pressurized source water (referred to as the "motive flow") to draw in air through a Venturi inlet, as in a whirlpool jet, an educator jet uses the Venturi effect to draw in or "entrain" water through the Venturi inlet. Consequently, part of the kinetic energy of the motive flow is transferred to the entrained flow, and the combined outlet flow from the educator is a multiple of the motive flow. The ratio of motive flow to outlet flow (the "entrainment ratio") is typically in the range of 3:1 to 5:1. Hence, the educator jet has the capability of multiplying the volume of water in the flow directed against the swimmer, thereby providing a stronger resistance for in-place swimming. Moreover, the educator-jet swimming pool of present invention is much more energy-efficient than the whirlpool-jet pool taught by the prior air, since the outlet flow from the educator jets is substantially laminar, thereby avoiding the internal energy losses of turbulent flow which occur in air-entraining whirlpool jets.

SUMMARY OF THE INVENTION

[0010] The present invention in its preferred embodiment uses one or more Venturi-based eductor jets that provide an augmented water flow within a pool enclosure to enable someone to swim in place against the flow. An eductor jet is type of pump in which the kinetic energy of a motive liquid is used to entrain a low-pressure liquid, completely mix the two, and then discharge the mixture as an augmented outlet flow. The energy from the motive liquid is transferred to the entrained liquid via the Venturi effect. As the motive liquid passes through a tapered nozzle, kinetic energy increases and pressure decreases. This produces a Venturi effect which draws liquid from the Venturi orifice into the flow stream.

[0011] By using eductor jets in a swimming pool, the kinetic energy of the water supplied to the jets is used to multiply the flow volume by entraining the pool water surrounding the jets. The educator jets generate an outlet flow that is 3 to 5 times the volume of the inlet flow. Consequently, the outflow from the eductor jets is much greater than the outflow from conventional jets or whirlpool jets for the same inflow. This augmented outflow provides much greater resistance for in-place swimming.

[0012] In the present invention, the inlet flow to the eductor jets is provided by conventional sources of swimming pool water, such as a water supply line, a pool pump, or a dedicated pump. Optionally, the volume of inlet flow can be controlled by a conventional multi-port valve or by a multi-speed pump, or by a combination of the two. Since the outlet flow will be a multiple of the inlet flow, control of the inlet volume can be used to adjust the strength of the outflow in accordance with the strength of the swimmer and their desired level of exertion. The eductor jets can be located either within the pool enclosure itself or within a dedicated jet enclosure which fluidly communicates with the pool enclosure. When the eductor jets are positioned within the pool enclosure, they will preferably be surrounded by a screen or other equivalent permeable barrier to prevent contact between a swimmer and the jets.

[0013] Optimally, multiple eductor jets are used to generate a broader and more uniform outflow. An array of eductor jets can include a combination of jets having two or more different inlet diameters to achieve a desirable comfortable combined outflow pressure. The array may comprise one or more horizontal rows of eductor jets to achieve a width and depth of the outflow current which is optimal for in-place swimming.

[0014] The use of eductor jets in the present invention allows a smaller pool to offer the recreational utility of a much larger pool in terms of continuous swimming time and distance. The eductor jets are superior to conventional jets and whirlpool jets because they can move greater volumes of water at the equivalent inlet pressure and volume. The pool of the present invention can be much shorter and more narrow and yet still provide the user a strenuous swimming workout. Thus, the eductor feature of the present invention reduces both space requirements and cost by reducing the overall pool footprint, reducing materials and construction costs, and reducing water pumping, filtering and heating costs. The present invention also promotes energy-conservation because it requires a much smaller volume of water to be pumped and heated while operating the pool.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. **1** is a side perspective view of the eductor jet used in the preferred embodiment of the present invention;

[0016] FIG. **2** is a front perspective view of the eductor jet used in the preferred embodiment of the present invention;

[0017] FIG. **3** is a back perspective view of the eductor jet used in the preferred embodiment of the present invention;

[0018] FIG. **4**A is a side cross-sectional view of the eductor jet used in the preferred embodiment of the present invention along the line shown in FIG. **4**B;

[0019] FIG. **5** is an overhead plan view of the preferred embodiment of the present invention, with an array of eductor jets located within the pool enclosure on the front wall of the pool;

[0020] FIG. **6** is a side profile view of the array of eductor jets shown in FIG. **5**;

[0021] FIG. **7** is a front elevation view of an alternate array of eductor jets on the front wall of the pool enclosure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0022] Referring to FIG. **5**, the present invention **10** comprises a swimming pool enclosure **11**, which is defined by a series of interconnected sidewalls **12** underlain by a bottom or floor **13**. A volume of pool water **14** is contained within the pool enclosure **11**. While, for illustrative purposes, the preferred embodiment depicted in FIG. **5** has a rectangular pool enclosure, the present invention applies to any pool enclosure configuration.

[0023] In fluid communication with the pool water **14** is an array of multiple eductor jets **15**. For illustrative purposes, the preferred embodiment locates the array of eductor jets **15** within the pool enclosure **11**, positioned along one of the sidewalls **12**, as shown in FIG. **5** and FIG. **6**. In the alternative, the array of eductor jets **15** can be located outside the pool enclosure, as long as it remains in fluid communication with the pool water **14**. Therefore, the present invention also includes the preferred embodiment described in application Ser. No. 11/896,998, which is incorporated herein by reference, and which discloses an eductor array enclosed in an eductor box that is separate from the pool enclosure but is in fluid communication with the water in the pool enclosure. When the array of eductor jets **15** is positioned within the pool enclosure **11**, they will preferably be surrounded by a screen or other equivalent permeable barrier **33**, as shown in FIGS. **5**-**7**, to prevent contact between a swimmer and the jets.

[0024] The exemplary eductor array **15** depicted in FIG. **5** and FIG. **6** has two horizontal rows of four educators each, but this configuration should not be regarded as limiting. On the contrary, the width and depth of the eductor array **15**, as well as the number and size of the educators comprising the array **15**, can be varied to produce any desired flow pattern and pressure in accordance with the pool owner's preferences. For example, the alternate eductor array **15** configuration shown in FIG. **7** features a top row **16** of six smaller educators with a bottom row **17** of three larger educators.

[0025] The eductor array **15** is fluidly connected to a pressurized water source, which can be a water line, a pool pump or a dedicated pump. For illustrative purposes in the preferred embodiment as depicted in FIG. **5**, the water source is a conventional pool pump **18**, which recirculates pool water **14** to a from the pool enclosure **11**, typically routing the pool water **14** through a filter and/or a heater (not shown). Optionally, the pool pump **18** can be a multi-speed pump, which would allow adjustment of the inlet flow rate to the eductor array **15**. Another optional feature to control the inlet flow rate is a multi-port valve **19** downstream of the pool pump **18**, which would allow some of the flow from the pool pump **18** to be diverted directly into the pool enclosure without going through the eductor array **15**. The use of either or both of these means of controlling the inlet flow rate to the eductor array **15** enables the swimmer to adjust the outflow rate to produce a level of resistance that matches their swimming strength and proficiency and/or their desired degree of physical exertion.

[0026] The preferred design of the individual eductor jets **20** comprising the eductor array **15** is illustrated in FIGS. **1**-**4**. The eductor jet **20** has an inlet opening **21**, through which the inlet flow **22** from the water source **18** is injected, and an outlet opening **22**, through which the outlet flow **24** from the eductor jet **20** is discharged into the pool enclosure **11**. Downstream of the inlet opening **21** is an inlet connector **25**, which is a means by which the inlet opening **21** can be secured in fluid connection to the water source **18**. For exemplary purposes, the illustrations of FIGS. **1-4** depict the inlet connector **25** as an externally threaded tubular neck.

[0027] Downstream of the inlet connector **25** is a converging nozzle **26** defining a fluid passage with a converging truncated-conical or frustum shape, such that its internal diameter decreases from the inlet to the outlet side. The shape of the converging nozzle **26** causes the flow rate of the water to increase in velocity, which results in a pressure drop due to the Venturi effect. Surrounding the converging nozzle **26** are one or more Venturi orifices **27**, through which the eductor jet is in fluid communication with the pool water **14**. The Venturi effect produced by the converging nozzle **26** results in a negative pressure in the Venturi orifice **27**, which has the effect of drawing an entrained flow **28** of pool water **14** into the Venturi orifice **27**. The entrained flow **28** mixes with the inlet flow **22** downstream of the Venturi orifice **27** to constitute a combined outlet flow **24**. Downstream of the Venturi orifice **27** is a diffuser **29**, which is a horn-shaped structure with a diverging internal diameter that increases from the downstream end to the upstream end. The increasing downstream cross-sectional area of the diffuser causes the velocity of the outlet flow **24** to decrease while its pressure increases as it passes through the diffuser **29**. The re-pressurized outlet flow **24** finally discharges from the outlet opening **22** and into the pool enclosure **11**, which it provides the resistance for in-place swimming.

[0028] In the exemplary eductor jet design of the preferred embodiment shown in FIGS. **1-4**, the Venturi orifice **27** is formed by four connecting struts **30**. The connecting struts **30** connect the converging nozzle **26** with the diffuser **29** while maintaining a gap between them which constitutes the Venturi orifice **27**. This design is optimal because it allows the entrained flow **28** of pool water **14** to enter the eductor jet **20** from every angle 360 degrees around it. Also as illustrated in FIGS. **1-4**, the preferred configuration of the diffuser **29** has a cylindrical-tubular upstream section **31** and a diverging frustum-tubular downstream section **32**.

[0029] This type of eductor jet is able to achieve entrainment ratios (ratio of inlet flow to outlet flow) in the range of 3 to 5 times. As these ratios show, eductor jets are much more efficient in generating high volume flows for in-place resistance swimming than other jets. For the same pressure input, eductors produce a much greater volume flow and a much greater energy and pressure of water flow. Thus, the use of the eductor jets is a very energy-efficient way of providing a relatively small footprint swimming pool with a vigorous current for stationary swimming.

[0030] Although the preferred embodiment of the present invention has been disclosed for illustrative purposes, those skilled in the art will appreciate that many additions, modifications and substitutions are possible, without departing from the scope and spirit of the present invention as defined by the accompanying claims.

What is claimed is:

1. A swimming pool comprising:

a pool enclosure defined by a series of interconnected sidewalls and an underlying floor and containing a volume of pool water;

an eductor array comprised of multiple eductor jets in fluid communication with the pool water and fluidly connected to a pressurized water source;

wherein the water source supplies an inlet flow to the eductor jets, and wherein the eductor jets multiply the volume of the inlet flow by creating a Venturi effect, which draws an entrained flow of pool water into the eductor jets and mixes the entrained flow with the inlet flow to generate an augmented outlet flow; and

wherein the volume of the outlet flow is a more than three-fold multiple of the volume of the inlet flow; and

wherein the outlet flow is discharge from the eductor jets into the pool enclosure, thereby generating a forceful current against which a swimmer can swim in-place.

2. The swimming pool according to claim **1**, wherein each of the eductor jets comprises:

an inlet opening, through which inlet flow enters the eductor jet;

an outlet opening, through which the outlet flow from the eductor jet is discharged into the pool enclosure;

downstream of the inlet opening, an inlet connector, which is a means by which the inlet opening is secured in fluid connection to the water source;

downstream of the connector, a converging nozzle, which defines a converging fluid passage that causes the velocity of the inlet flow to increase as the inlet flow passes through the converging nozzle, thereby resulting in a fluid pressure drop across the converging nozzle that produces a Venturi effect;

downsteam of the converging nozzle, one or more Venturi orifices, through which the eductor jet is in fluid communication with the pool water, and through which the entrained flow of pool water is drawn into the eductor jet;

downstream of the Venturi orifice, a diffuser, which is a horn-shaped structure defining a diverging fluid passage; wherein the entrained flow of pool water mixes with the inlet flow within the diffuser to generate the augmented outlet flow, and the velocity of the outlet flow decreases while the pressure of the outlet flow increases as the outlet flow passes through the diffuser.

3. The swimming pool according to claim **2**, wherein each of the eductor jets further comprises mulitple struts, which connect the converging nozzle with the diffuser while maintaining a gap between the converging nozzle and the diffuser, wherein the gap defines the Venturi orifice, thereby allowing pool water to flow into the Venturi orifice from every angle in a range of 360 degrees around the eductor jet.

4. The swimming pool according to claim **3**, wherein the diffuser comprises a cylindrical-tubular upstream section and a diverging frustum-tubular downstream section.

5. The swimming pool according to any one of claims **1-4**, wherein the array of eductor jets is located within the pool enclosure and is surrounded by a permeable barrier which protects the eductor jets from physical contact.

6. The swimming pool according to any one of claims **1-4**, further comprising one or more means for controlling the volume of the inlet flow so as to adjust the volume and force of the outlet flow, thereby accormodating various levels of swimming ability, intensity and stamina.

7. The swimming pool according to claim **5**, further comprising one or more means for controlling the volume of the inlet flow so as to adjust the volume and force of the outlet flow, thereby accormodating various levels of swimming ability, intensity and stamina.

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