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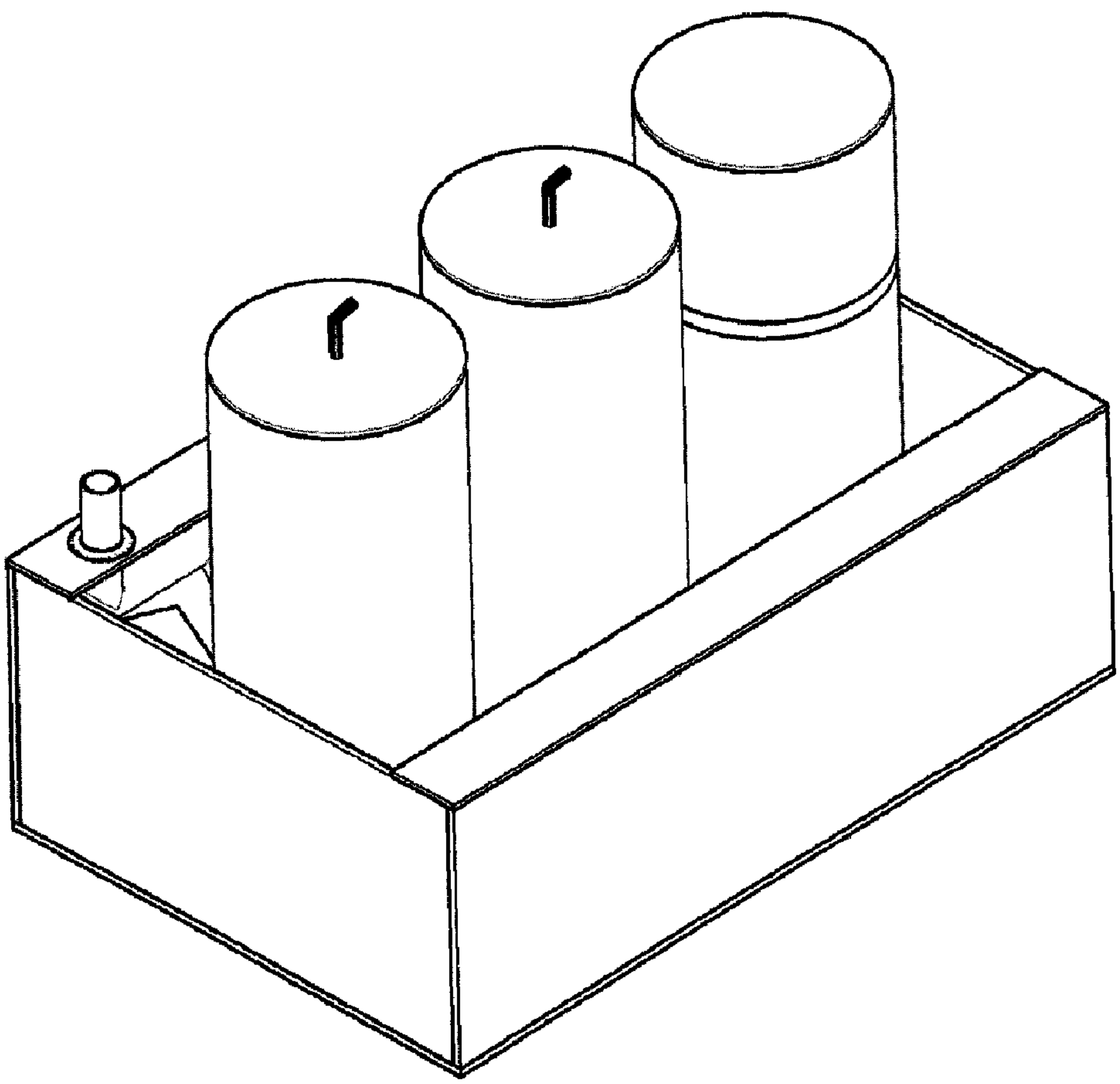
(54) Titre : NOYAU DE REACTEUR A PUISARD POUR FILTRATION D'AQUARIUM
(54) Title: SUMP REACTOR HUB FOR AQUARIUM FILTRATION



(57) Abrégé/Abstract:
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(57) Abrégé(suite)/Abstract(continued):
plenum partitions which direct the passage of aquarium water through all requisite stages of a given reactor system. Controlled hydrological communication between each reactor and its respective sub-plenum zone is achieved through a given pattern of access points; self-sealing gaskets; and plenum/reactor connectors. Undesirable hydrological communication is contained by the appropriate usage of plug and/or valve assemblies. Each reactor may be completed by a dedicated outlet or drainage assembly connected via the same plenum system if not intrinsic to the actual reactor construction. The present invention organizes all hydrological services within a zoned plenum system as a means to allow for modular manipulation of any given aquarium filtration strategy. To this end a disparate variety of reactor types are described to complete this modular filtration system. Such reactors are purposed to address all forms of chemical, biological, and mechanical filtration/augmentation of aquarium water.

Sump Reactor Hub for Aquarium Filtration

ABSTRACT:

A sump reactor hub utilizes a zoned plenum system to organize supply, drain, and/or recirculation through one or multiple reactor vessels, purposed for filtration and/or augmentation of aquarium water. Each plenum zone comprises complete and partial sub-plenum partitions which direct the passage of aquarium water through all requisite stages of a given reactor system. Controlled hydrological communication between each reactor and its respective sub-plenum zone is achieved through a given pattern of access points; self-sealing gaskets; and plenum/reactor connectors. Undesirable hydrological communication is contained by the appropriate usage of plug and/or valve assemblies. Each reactor may be completed by a dedicated outlet or drainage assembly connected via the same plenum system if not intrinsic to the actual reactor construction. The present invention organizes all hydrological services within a zoned plenum system as a means to allow for modular manipulation of any given aquarium filtration strategy. To this end a disparate variety of reactor types are described to complete this modular filtration system. Such reactors are purposed to address all forms of chemical, biological, and mechanical filtration/augmentation of aquarium water.

SPECIFICATION:

Field of Invention

The present invention relates generally to an aquarium filtration system, and more particularly to an aquarium sump specifically designed to accommodate a multitude of specialty purposed; readily removable and replaceable reactor vessels, hereafter referred to as 'reactors' of varied design and function to facilitate disparate forms of water filtration within a single unit or multiple thereof. The present invention forms an aggregative solution which provides an evolution based, interchangeable alternative to aquarium filtration strategies.

Background of Invention

Filters are required for fresh and saltwater aquariums to facilitate mechanical removal of unwanted particulates; biological transformation of toxic residuals; and chemical neutralization of organic compounds; all of which are produced by aquarium inhabitants. Further specialized aquarium habitats such as those heavily stocked with plants; or those which require oligotrophic conditions with the provision of specific trace elements such as in coral reefs, require purpose focused reactors of various function to facilitate additional tasks within the entire water processing or filtration system.

Aquarium sumps, and sump based filters are employed when an increased capacity for water purification and/or augmentation is required. The early sump filters were designed to accommodate large volumes of elevated media upon which aquarium water is percolated in a manner to expedite the conversion of harmful nitrogenous compounds via the process of aerobic biological filtration. Water percolated through such media would then collect within a larger sump container prior to its recycling through the aquarium environment. Early sump filters provided numerous advantages including but not limited to: increased bio-filtration capacity; increased access to filter media; increased oxygen saturation levels; as well as an increased opportunity for purpose driven filtration refinement.

The increase of scientific and practical knowledge within the realm of aquarium husbandry has lead to a demand for many individually purposed types of equipment, hereafter referred to as 'reactors'. The various reactors have been designed to function either inside and/or outside of the aquarium sump container and serve to augment aquarium water conditions in a manner toward the natural environments from which the subject inhabitants originate. A few examples of such reactors are foam fractionators; calcium reactors; carbon dioxide reactors; phosphate reactors; kalkwasser reactors; denitrification reactors; sulphur reactors; etc. In-sump reactors often serve as the favourable option for several reasons relating to spatial constraints; minimized leak risks; or even for purposes of consolidating hydrological access and flow-through.

It has also been found that several types of reactors are optional based on the adopted strategy and particular style of husbandry chosen by any given aquarist. Although equipment such as foam fractionators (more commonly known as protein skimmers) are considered a fundamental necessity for the creation of a healthy marine environment, this particular piece of equipment is not typically employed in any such freshwater system. As well, a piece of equipment used for dissolving carbon dioxide (CO_2) into aquarium water is referred to as a CO_2 reactor and is of fundamental necessity to achieve success in a freshwater planted aquarium, but is no longer used with any dominance within salt water aquarium environments.

Additionally, in saltwater aquariums, the difference between 'fish-only' and reef environments is also fundamentally reflected in the types of equipment employed to filter and augment the quality of water. The invertebrates found in reef environments for example, require such a high level of water purity that phosphate reactors are used to maintain the lowest possible phosphate levels; trickle type biological filters are often foregone to limit nitrate production; and denitrification reactors provide an option to further eliminate any residual nitrates produced by the metabolic activities of the contained livestock. Such strategies are seldom employed for fish-only marine aquariums.

Still of consideration is the availability of a variety of reactor types to achieve a similar purpose. Maintaining optimum levels of calcium for example can be obtained without the use of a reactor by dosing any one of many available liquid or dry-form additives. However there are currently two primary types of commercially available reactors to achieve the same purpose via a more economical strategy. Calcium reactors utilize CO_2 to dissolve calcium ions from a chosen calcareous media. The subsequent calcium rich solution then flows into the aquarium to maintain optimum calcium levels tuned between 400 – 500 mg/L (ppm). As a consequence of the same process, carbonate hardness is also maintained at optimal levels between 9 – 12 dKH. Alternatively, the use of a limewater or 'kalkwasser' reactor directs aquarium top-off water through a saturated solution of calcium hydroxide (kalkwasser), located within a vessel equipped with an automated agitation mechanism, prior to its destination within the aquarium environment. The positive consequence introduced by the use of kalkwasser is the precipitation of phosphate. Aquarists have the option of using any one or combination of the aforementioned strategies for calcium ion supplementation.

It is also recognized that dedicated aquarists are committed to maintaining the best possible equipment available so long as budget allows. This can be a markedly difficult task as much of the core reactors are subject to regular design and improvement iterations which include the latest improvements to their operational effectiveness. Such a reality can be unfortunately costly and intimidating to many dedicated hobbyists who do not have the benefit of an inexhaustible income nor the type of hobby budget that would allow them to replace entire functional reactors, complete with dedicated circulation and/or recirculation equipment to match the availability of new upgrades or improvements provided by an ever-evolving industry. It is further recognized that many aquarist evolve their philosophical approach to aquarium husbandry several times through their accumulations of industry-wide knowledge and empirical experience.

As can be seen there are disparate needs for the various reactors available to the aquarium industry. It can also be reckoned that there exists a need for a system which provides a significant measure of flexibility, and affords the best possible efficiency to aquarist still evolving their approach to aquarium husbandry.

Accordingly, it is an object of this invention to provide a system in which aquarium reactors are readily replaceable and interchangeable with minimal effort and expense in a manner to afford all aquarists an economical option of equipment exchange as they evolve personal philosophies toward aquarium husbandry.

It is a further object of this invention to standardize a hydrological delivery system while providing a mechanism of simplified interchange ability and reuse of those resources fundamental to the various types of reactors independently of each upgrade.

It is yet a further object of the present invention to provide a practical solution of flexibility to afford aquarists the ability to share sump real estate between multiple reactors, based on calculated strategy or prescribed necessity. A bio-tower, for instance, can be replaced by a denitrification reactor or an additional skimmer simply and practically synchronized with the evolution of one's philosophical methodology.

It is a further object of the present invention to mitigate the total cost of process evolution by means of standardizing provisions of hydrological supply such that equipment upgrades can be isolated to individual components such as the actual reactor, or pump(s) as opposed to the reactor and pump(s).

Description of Prior Arts

The concepts and approaches to aquarium filtration have been in a constant state of evolution over the past several decades. Canadian Patent No. 2,249,553 entitled "Aquarium Undergravel Filter" describes one of the earliest methods of facilitating the phenomenon of aerobic biological filtration. Through this design, a perforated plate supports the aquarium's gravel bed in a position slightly elevated above the actual aquarium bottom. A modest but consistent flow of water is then induced through provided lift tubes which are in turn connected to the underside of the aforementioned perforated plate. The result is a constant flow of water navigated through the aquarium's gravel bed, at which point biological waste created by the aquarium inhabitants are consumed by a population of nitrifying bacteria established throughout the gravel bed. The Undergravel filter has served as one of the simplest life support systems the aquarium trade has ever benefited from.

Canadian Patent No. 1,086,580 entitled "Aquarium Filtration Apparatus" describes one of several iterations of the hang-on type power filter. A hang-on filter employs a magnetically driven impeller to siphon water over the rim of a subject aquarium into its external rim-mounted filtration housing. Within such an external housing, waste laden water is navigated through a variety of filter media prior to overflowing back into the subject aquarium. The hang-on type power filter provided several benefits with its simplistic design. Its external mount simplified access to clean and exchange clogged or spent media. It also increased the ease at which mechanical and chemical forms of filtration can be used to enhance and augment aquarium water quality.

A further development to the external power filter can be seen in the canister type filter which can be located away from the aquarium's area of focus. The canister filter adds benefits of increased size and filtration capacity to the prior successes of the hang-on type power filter. Canadian Patent No. 2,145,151 entitled "Filter for Aquariums" presents an advanced iteration of the canister type filter. This design adds a mechanism of aerobic enhancement to the canister concept by allowing its filtration volume to alternate between a variable supply of air and aquarium water. The net result of such an implementation is a greater capacity for biological filtration, neatly contained within the confines of a media filled canister.

Canadian Patent No. 2,579,565 entitled "Modular Aquarium Filter" presents a solution of flexibility within a neatly contained filtration apparatus. This particular patent utilizes a series of media compartments which connect in series to facilitate a utilitarian and expandable filtration strategy. The design allows for any number of compartments to be assembled in a manner to facilitate all forms of mechanical, biological and chemical filtration, as determined by the bio-load of a subject aquarium. The design also intends for any single media compartment to be removed from the complete system without risk of leakage or disturbance to the remaining cartridges. Although this modular filter excludes a self contained pump conveyance system, it does successfully add the concept of modular flexibility to the aforementioned strategies of external filtration.

United States Patent No. 6,436,295 B2 entitled "Protein Skimmer" represents a solution to facilitate the phenomenon known to aquarists as foam fractionation. Foam fractionation utilizes processes of positive and negative ionic attractions to facilitate aquarium waste removal in the form of 'protein' prior to its degradation into toxic nitrogenous compounds within the aquarium system. A Protein Skimmer can be simplified in concept to an apparatus which facilitates the production of foam, and accommodates the interaction between such foam and waste-laden aquarium water as a means to disassociate the waste/protein from the aquarium water and bind the same to an abundant supply of air bubbles which subsequently rise to a protein collection cup as a measure to permanently remove polluting organics from the aquarium water. The most successful protein skimmers provide a turbulent mix of aquarium water infused with infinitely fine and numerous bubbles; prolong the reaction time between waste-laden aquarium water and bubbles; and provide a zone for dry, dirty foam liberation from the aquarium water prior to the latter's return as a waste-diminished product. Protein skimmers are considered of fundamental necessity to the success of all marine aquarium environments, and represent a history of constant refinement within the aquarium trade.

Yet another design which represents a combination of filtration mechanisms is detailed in United States Patent No. 7,094,335 B2 entitled "Aquarium Filtration System". This particular design has formalized a filtration strategy which combines the common elements utilized within a marine aquarium system. In particular it utilizes a sump container which houses a mechanical pre-filter, which in turn serves as the precursor to individual steps of foam fractionation and aerobic biological filtration in the form of a trickle-type, or wet/dry bio-tower. The design identifies several strategies that have been used either individually or in numerous combinations in many saltwater aquariums around the world. However, what is noteworthy of such a system is the use of a common sump which consolidates filtration hydrology within a single container that is gravity fed from the aquarium above, and utilizes at least one return pump to complete the hydrological connection between the aquarium and its respective filtration system.

The current invention focuses on the utility of combining multiple filtration strategies within a shared sump. Its enhancement to the art of aquarium husbandry is found in its modular approach to filtration expandability and convenient modification.

Summary of the Invention

A sump reactor hub comprising of a reservoir container, complete with a zoned plenum divided in a manner to accommodate any combination of a single or series of interchangeable reactors, wherein each individual reactor can be connected in a water-sealed manner to the sub-plenum zone in order to access hydrological supply; drain; or recirculation facilities.

The said reactor hub is to contain a strategic pattern of dimensionally standard holes which provide interchangeable reactors access to the sub-plenum level, while appropriately installed seals disallow fluid leakage between super and sub-plenum zones of the said hub.

The sub-plenum level is strategically divided by a pattern of full; semi-top; and semi-bottom barriers to purposefully direct the passage of fluid between each reactor; its respective plenum zone; and the shared sump.

A foam reactor designed to connect to the said reactor hub in a manner to facilitate receipt of supply; drain; and/or recirculation services through said plenum system. The foam reactor will operate as a conventional foam fractionator (also known as a protein skimmer) to facilitate the removal of aquarium waste products (protein) via the interaction of aquarium water and foam.

A mechanical reactor designed to connect to the said reactor hub in a manner to facilitate receipt of supply; drain; and/or recirculation services through said plenum system. The mechanical reactor will utilize media such as filter floss or engineering foam and the like, appropriate for the physical removal of solid waste from aquarium water.

An aerobic bio-reactor designed to connect to the said reactor hub in a manner to facilitate receipt of supply; drain; and/or recirculation services through said plenum system. The aerobic bio-reactor will operate as a conventional biological filter to expedite the conversion of toxic nitrogenous compounds to less toxic nitrates.

A chemical reactor designed to connect to the said reactor hub in a manner to facilitate receipt of supply; drain; and/or recirculation services through said plenum system. The chemical reactor will accommodate media such as activated carbon or other such chemically absorptive material commonly used to remove undesirable organic compounds from aquarium water.

A denitrification bio-reactor designed to connect to the said reactor hub in a manner to facilitate receipt of supply; drain; and/or recirculation services through said plenum system. The denitrification bio-reactor will accommodate inert and/or chemically active media within an anaerobic or anoxic micro environment purposed to destructively remove; neutralize; or assimilate nitrates from aquarium water.

A phosphate reactor designed to connect to the said reactor hub in a manner to facilitate receipt of supply; drain; and/or recirculation services through said plenum system. The phosphate reactor will accommodate conventional media such as ferrous-oxide or aluminum hydroxide known to absorb phosphates dissolved in aquarium water.

A carbon dioxide (CO_2) reactor designed to connect to the said reactor hub in a manner to facilitate receipt of supply; drain; and/or recirculation services through the said plenum system. The CO_2 reactor will use appropriate media and hydrological recirculation to dissolve supplied CO_2 into aquarium water.

A calcium reactor designed to connect to the said reactor hub in a manner to facilitate receipt of supply; drain; and/or recirculation services through the said plenum system. The calcium reactor will use conventional media as well as an external carbon dioxide supply system to facilitate the supply of calcium ions to the aquarium system.

A kalkwasser reactor designed to connect to the said reactor hub in a manner to facilitate receipt of supply; drain; and/or recirculation services through the said plenum system or auto top-off mechanism. The kalkwasser reactor will use appropriate media/reagents as well as an automated agitation mechanism to facilitate the supply of calcium ions to the aquarium system.

A Refugium reactor designed to connect to the said reactor hub in a manner to facilitate receipt of supply; drain; and/or recirculation services through the said plenum system. The refugium reactor will be used to propagate algae and/or micro-fauna within a controlled environment free of predation in order to provide a natural means of algae-feeding nutrient reduction; and live food production in service to the greater aquarium environment.

In method form the present invention comprises a method of connecting separately purposed reactors and respective circulation mechanisms to a single sump via a zoned plenum system whereby each zone organizes hydrological flow into categories of reactor supply, reactor drain, and reactor recirculation, and each access point is appropriately sealed to prevent undesirable transmission of fluid between plenum zones and the shared sump container.

The present invention further comprises a method of adding individual reactors to a single sump to afford aquarists ease of expansion within an existing sump filtration system.

Brief Description of the Drawings

These and other objects, features and advantages of the present invention will become more apparent from the following description and claims considered in conjunction with the accompanying drawings, where like reference numbers indicate identical or functionally similar elements.

FIG. 1 is a schematic isometric view of the present invention with the leading side and front panels removed to disclose its interior composition and three sample reactors with indication of suggested hydrological services;

FIG. 2 is a schematic exploded isometric view of the embodied layout represented in FIG. 1, indicating the primary relationships between sub-plenum zones; hydrological connections; and sample reactors also indicated in FIG. 1;

FIG. 3 depicts a long sectional view of a sample layout, taken through the midpoint of the represented embodiment;

FIG. 4 depicts a cross sectional view of a sample layout, taken just beyond the midpoint of the represented embodiment;

FIG. 5 is a schematic section isometric taken along the midpoint of the represented embodiment;

FIG. 6 is an exploded section isometric indicating the internal representations of the exploded isometric depicted in FIG. 2.

Detailed Description of the Invention

The present invention utilizes a zoned plenum system and strategically arranged access points to add new efficiencies to the problem of aquarium filtration and strategic modification by addition and/or subtraction of a wide variety of reactors useful to the art of aquarium husbandry. A detailed description of a suggested embodiment is provided below. While the invention is described in conjunction with that embodiment, it should be understood that the invention is not limited to any one embodiment. Rather, the scope of the invention is limited only by the appended claims, and the invention encompasses numerous alternatives, modifications and equivalents. Specific details are set forth in the following description for the purpose of example, in order to provide a thorough understanding of the invention. The invention may be practiced according to the claims without some or all of the presented specific details.

As shown in **FIG. 1**, the aquarium filtration system **25** of the present invention comprises a plurality of reactor vessels **4**, **5**, **6** connected through plenum boundary **2** to access sub-plenum zone **3** of sump container **1**. Undesirable communication of fluid between sub-plenum zone **3** and general sump volume **26** is controlled by the use of self-sealing gaskets **9** and plug assemblies **10**.

It is to be understood that any number and combination of reactor types can be employed within the scope of the present invention, however for the purpose of thorough conveyance of this particular embodiment, reactor vessel **4** is depicted as a foam fractionator hereafter referred to as a Foam Reactor; reactor vessel **5** will be depicted as a sulphur based denitrator hereafter referred to as a Nitrate Reactor; and reactor vessel **6** will be depicted as a calcium reactor hereafter referred to as a Calc Reactor.

As can be seen in **FIG. 1**, all reactors **4**, **5**, **6**; circulation and recirculation pumps **8**; optional external supply feeds **7**; and reactor drainage assemblies **11** are each connected to the filtration system through the plenum boundary **2**, into the sub-plenum zone **3**, and completed by self-sealing gaskets **9**.

Stacking of the primary components of the present invention is depicted in **FIG. 2**. The exposed sub-plenum zone **3** is comprised of a strategic arrangement of reactor/zone isolation barriers **12**; partial lower flow partitions **13**; partial upper flow partitions **14**; and full internal partitions **15**. It is further clarified that fluid routed through each individual reactor shall not interact undesirably at the sub-plenum level prior to its wilful dispatch into the greater sump volume **26** by means of controlled exit provisions as exemplified by reactor drainage assembly **11**; or separate reactor specific outlets **27** and **28**.

In order to standardize the present invention with the inherent flexibility to accommodate a disparate array of purpose specific reactor vessels, a predetermined pattern of access points **29** is designed to purposefully relate to the various sub-plenum areas and divisions described above. Nominally sized plug assemblies **10**, are provided for discretionary employment to decommission any access points which become redundant to the operation of any given reactor.

Circulation/recirculation pumps **8** also bypass plenum boundary **2**, via provided access points **29** to connect into sub-plenum zone **3**. A wide variety of available pumps can be fitted to mate with this invention, as determined by size and flow requirements of each desired reactor. In addition, it can be arranged that any such reactor be provided with an additional circulation/recirculation pump **8'** to boost a respective reactor's efficiency as in the case of Foam Reactor **4**.

A deliberate pattern of full partitions **15**; partial lower flow partitions **13**; and partial upper flow partitions **14**, allows for all reactor circulation and feed requirements to occur through plenum boundary **2**, and sub-plenum zone **3**. Per the discretion of the aquarist, this can be achieved either via induction by circulation/recirculation pump **8**, or by means of installing an optional external supply feed **7**. The external supply feed **7** may in turn serve as the conduit of a separately dedicated circulation pump; or may in fact be gravity fed from the main display aquarium located above the level of the present filtration system. In such instances supply control valves **16** are provided to refine the rate of aquarium water to be fed through each respective reactor vessel.

A group of access points typically exemplified as **29a**, **29b**, **29c**, **29d**, and **29e**, normally but not exclusively located central to each reactor's spatial allocation, serve as attachment facilities for a given reactor vessel. Each reactor vessel **4**, **5**, and **6** is mated with its respective group of access points in a manner of stable connection to its portion of the sub-plenum zone **3**.

The long sectional view depicted by **FIG. 3** illustrates some of the many potential functionalities and connections between a given reactor and the sub-plenum hydrological system resolved by the present invention. In the current embodiment, Foam Reactor **4**, Nitrate Reactor **5**, and Calc Reactor **6** are each provided with a stable plenum/reactor connector **20**. Such a connection is steadfastly secured to the reactor vessel, however employs the same frictional means of connection through plenum boundary **2** via self sealing gasket **9** typical with all other vessel and service connections to the present filtration system. This stable connection **20** can be achieved by several means, most typical of which would be a mechanical method through the use of a standard bulkhead; or by a chemical bonding process made possible by an appropriately selected adhesive.

Nitrate Reactor **5**, and Calc Reactor **6** are operationally similar in their design as 'media reactors'. Each media reactor utilizes a group of access points previously described by 29a, 29b, 29c, 29d, and 29e (FIG. 2) to facilitate mechanics of reactor feed, and reactor recirculation. Though any given reactor, by manipulation of its respective pump and plenum connections, can be arranged to readily accommodate either upwardly or downwardly directed hydrological flow through its volume of media, many skilled aquarists are aware that both calcium reactors and sulphur denitrators have been found to operate with greater efficiency when aquarium water is circulated upwardly through their respective medias. To this end, and for the purposes of clearly conveying the intent of this particular embodiment, the mechanics of Nitrate Reactor **5** and Calc Reactor **6** are similarly described as follows:

Aquarium water enters the media reactor by controlled feed into the suction side of the recirculation pump 8, where it is mixed with water already in circulation through the subject reactor prior to being directed into its respective portion of sub-plenum zone **3**. From the sub-plenum zone, the described mix of fresh and recirculated aquarium water enters the reactor vessel through an appropriate number of connectors **17** as well as stable connector **20**, below a bottom diffuser plate **19**. Connectors **17** and **20** may be equipped with angled outlets as required to evenly mix and disperse aquarium water below the aforementioned diffuser plate **19**. Each diffuser plate **19** is prepared with a number of appropriately sized perforations purposed to adequately temper overly aggressive turbulence prior to aquarium water entering the reactor's interactive zone **30**. The tamed mix of aquarium water upwardly commutes through the selected media or mix thereof contained within the reactor's interactive zone **30**. In the case of Nitrate Reactor **5**, interactive zone **30** may contain both elemental sulphur, and a supply of porous media which combine to accommodate the type of bacteria that reduce nitrate to nitrogen gas. In the case of Calc Reactor **6**, interactive zone **30** will contain a prescribed type of calcareous media which when fed by acidified aquarium water will liberate calcium ions for subsequent delivery into the greater aquarium system. Following the activities designed to occur within each vessel's interactive zone **30**, the treated aquarium water will continue through a second diffuser plate **19'**, into exit/recirculation zone **31**. Within this zone **31**, a portion of water equal to the amount entering into the reactor, will exit the reactor vessel via reactor outlets **27/28**, to be directed either toward another reactor system for subsequent augmentation, or back into the greater aquarium system. The remaining portion of water within zone **31** will be redrafted for circulation via media by-pass/plenum connection **18** and its respective plenum zone **3**, where it will be accessed by recirculation pump 8; mixed with incoming aquarium water; and recycled through the feed side of the same reactor apparatus.

Foam Reactor **4**, bears many characteristics similar to the media type reactors **5** and **6**. A primary difference with regard to the function of reactor **4** is the desire for a downward water flow through interactive zone **30'**. It is conventional knowledge within the realm of protein skimmer design, that counter-current hydrodynamics within a skimmer's reaction chamber serves as a more efficient means to facilitate the process of protein to bubble ionic attachment. To this end, aquarium water is fed into Foam Reactor **4**, at an elevated point within interactive zone **30'** via the mid-reactor supply/plenum connector **21**. Connector **21** also possesses an angled outlet to achieve favourable dispersion within interactive zone **30'**. As a result of this particular reactor's employment of a drainage assembly identified as item 11 on FIG. 1, also connected to sub-plenum zone **3** and bound by the appropriate zone partitions, exit-flow of aquarium water may be directed downwardly from interactive zone **30'** through the lower diffuser plate **19** and into the sub-plenum zone **3** via an appropriate connector **17**. While in its downward flow through interactive zone **30'**, aquarium water is stripped of undesirable dissolved organic compounds and proteins by process of ionic attraction to a controlled mix of bubbles, produced by recirculation pumps 8 and 8' which are delivered upwardly through the lower diffuser plate **19** in a manner similar to that described for the aforementioned media reactors **5** and **6**.

Another difference made evident by the illustration of Foam Reactor **4** is the upper portion, representative of a means of protein export commonly referred to as a skimmer collection cup. A well functioning collection cup provides an uninhibited means of exhaust to relieve the volume of air intrinsic to the production of foam; it provides an inner riser **32** where dirty, protein laden foam can emerge; and a protein collection area **24** where dirty skimmate may be staged prior to its disposal by the aquarist. It can also be noted that dry protein laden foam is most efficiently separated from a wet bubble mix in the presence of a concentric cylindrical reduction. To this effect, it is an inherent benefit that the inner riser area **32** is diametrically smaller than interactive zone **30'**.

The cross section illustrated in **FIG. 4** provides an alternate view of some primary relationships resolved by the present invention. A typical media reactor is mounted onto plenum boundary **2**. Reactor/plenum connectors **17**, **18**, and 20 stemming from sub-plenum zone **3** enter through sealed reactor base **23**. A typical media reactor's interactive zone **30** is bound by perforated diffuser plates **19** and **19'**, between which any selection of purpose-specific media may be employed to achieve a desired form of aquarium water filtration/augmentation. Of the provided reactor/plenum connectors, a media by-pass **18** is used as desired to accomplish the required flow direction necessary for the operation of each reactor type. Within the bounds of sub-plenum zone **3**, each connector (**17**, **18**, and 20) is detailed for hydrological access **22**, to readily accommodate the passage of aquarium water in and out of each respective reactor.

The optional external supply feed **7** when employed is designed to access any subject reactor via its respective sub-plenum zone **3** according to the typical means of connection to plenum boundary **2**. In such instances where an external feed **7** is desired for certain but not all reactors in a given filtration system, a supply control valve **16** may be employed to isolate any given reactor from this particular supply mechanism. It is also clear that plug assemblies **10** can also be used to decommission access points considered obsolete or redundant to the operation of any given reactor.

Access points 29 adjacent to each reactor are allocated to accommodate any of the required functions of reactor supply, drain, and/or recirculation. In instances where a dedicated or external feed **7** is not employed, aquarium water may be induced into a given reactor by feed/recirculation pump **8**. The egression of aquarium water may be accomplished through reactor outlets (27/28) or drainage assemblies (**11**). Furthermore, where there can be benefits from increased circulation within a given reactor, such as in the case of Foam Reactor 4, a second recirculation pump **8'** can be readily added within the standard pattern of access points 29 provided within the scope of the present invention.

FIG. 5 illustrates a sectional isometric depiction of the embodied filtration system. The primary relationships between each reactor; its modes of circulation; and most importantly, its particular plenum zone are representative of the fundamental resolution of the present invention. In addition, it has been a specific goal of the present invention to practically afford the widest breadth of flexibility within any given strategy of aquarium filtration. To this end, the following process flow can be considered for the sample assembly of reactors already described for this particular embodiment of the present invention:

In an application to sustain a sample saltwater reef environment, the present invention will combine Foam Reactor **4**, Nitrate Reactor **5**, and Calc Reactor **6** as a primary strategy for aquarium water filtration/augmentation. Aquarium water will be induced into sulphur based Nitrate Reactor **5** via a feed/recirculation pump **8** through a valve-controlled inlet. Within this particular reactor, aquarium water will flow upwardly through two distinctly stacked media types: an inert, high porosity media will rest directly on top of diffuser plate **19**; and a relatively thin layer of elemental sulphur will rest directly on top of the aforementioned media. The porous media is intended to provide an abundance of real estate for denitrifying bacteria, while the sulphur is provided as a food source for the same bacteria. Within this particular reactor system, the hydrology will be subject to dominant recirculation, with a relatively small flow-rate of water exiting through reactor outlet **27**.

It is known that the effluent of any denitrification system has an extremely acidic characteristic. For this reason the outlet from Nitrate Reactor **5** leads directly to the feed inlet of Calc Reactor **6**. Calcium reactors in general use a carbon dioxide ($CO2$) supply system to dissolve calcium and calcium carbonate from a selected type of calcareous media. Because such media has a tendency to compact and channel as a consequence of its degradation, an upward flow of circulation is also opted for within Calc Reactor **6**. In a similar manner to that of Nitrate reactor **5**, aquarium water is induced into this reactor through the sub-plenum zone **3** where it is predominantly recirculated, with a relatively small flow rate of calcium rich effluent exiting through reactor outlet **28**. In addition to the acidic effluent received from reactor **5**, Calc Reactor **6** will also receive CO2 from a separate supply system.

Yet again, the effluent of Calc Reactor **6** will be routed directly into Foam Reactor **4**. Although reactor **4** will also be supplied with aquarium water drafted directly from the surrounding sump area, the extreme process of aeration intrinsic to the operation of any properly functioning protein skimmer provides a valuable degassing service which will relieve aquarium water from unwanted compounds present in the effluents of both reactors **5** and **6**. Latent hydrogen sulphide; nitrogen gas; and carbon dioxide may all be present in the effluents of reactors **5** and **6**, and will be substantially reduced, and even eliminated following adequate aeration within Foam Reactor **4**.

FIG. 6 uses an exploded section isometric to further illustrate the connections of each reactor (**4**, **5**, and **6**) to the plenum boundary **2**, and overall sump container **1**. It is again made clear that the core functionality of the present invention is derived from its strategic use of a zoned plenum system **3** and self-sealing gaskets **9** to execute sound hydrodynamics in a manner to completely organize the services of each employed reactor type. All possible circulation and recirculation facilities (**7** and/or **8**) are separately attached to any portion of the plenum zone **3** so that required manipulations to any given reactor can be executed separately from its particular hydrological provisions based on the needs and desired strategies employed by the aquarist.

While the invention has been described in complete detail and graphically illustrated in the accompanying drawings, it is not to be limited to such details, since many changes and modifications may be made to the invention without departing from the spirit and the scope thereof. While the above detailed description has shown, described, and pointed out fundamental novel features of the invention as applied to the presented embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the system illustrated may be made by those skilled in the art, without departing from the intent of the invention. The present invention is intended to employ a strategy of 'plug n play', in a manner to accommodate a comprehensive variety of reactor types hereafter described in the following claims.

CLAIMS:

What is claimed is:

1. A reactor hub comprising:

a sump complete with an integral plenum system wherein said plenum system is divided by full and partial barriers to facilitate and direct sub-plenum hydrological flow;

Wherein said plenum facilitates hydrological supply; drain; and recirculation to; from; and within one or more in-sump reactors;

Wherein said plenum is connected to in-sump circulation and/or recirculation facilities to accommodate hydrological flow into; out of; or within each such reactor;

Wherein transitions between said plenum and each said reactor is completed with self-sealing gaskets to prevent undesirable leakage between said plenum; shared sump; and each such reactor.

2. The reactor hub of claim 1 comprising any single or combination of a plurality of optional reactors.

3. The reactor hub of claim 1 wherein said reactors of claim 2 are frictionally engaged to said plenum system.

4. The reactor hub of claim 1 wherein one or more reactors of claim 2 utilizes foam fractionation to achieve protein removal.

5. The reactor hub of claim 1 wherein one or more reactors of claim 2 provide mechanical filtration.

6. The reactor hub of claim 1 wherein one or more reactors of claim 2 provide aerobic biological filtration.

7. The reactor hub of claim 1 wherein one or more reactors of claim 2 provide chemical filtration.

8. The reactor hub of claim 1 wherein one or more reactors of claim 2 provide anaerobic biological filtration.

9. The reactor hub of claim 1 wherein one or more reactors of claim 2 provide anoxic biological filtration.

10. The reactor hub of claim 1 wherein one or more reactors of claim 2 provide nitrate reduction.

11. The reactor hub of claim 1 wherein one or more reactors of claim 2 provide phosphate reduction.

12. The reactor hub of claim 1 wherein one or more reactors of claim 2 provide carbon dioxide saturation.

13. The reactor hub of claim 1 wherein one or more reactors of claim 2 provide calcium ion supplementation.

14. The reactor hub of claim 1 wherein one or more reactors of claim 2 provide a refuge environment for macro algae and/or micro-fauna production.

15. A device for directing water through a multitude of reactors, said reactors are connected to a common sump via a zoned plenum system, said sump is further connected to one or more pumps via the same plenum system, each reactor and pump connection to said plenum is competed by a self-sealing gasket.

16. The device of claim 15 wherein the one or more reactors provide foam fractionation, mechanical filtration, biological filtration, chemical filtration, nitrate reduction, phosphate reduction, carbon dioxide saturation, calcium ion supplementation, algae based filtration, and/or micro-fauna production.

17. The device of claim 15 wherein any of said one or more reactors contain mechanical, biological, or chemical filtration media.

18. The device of claim 15 wherein each reactor is connected to said plenum system independently.

19. The device of claim 15 wherein two or more reactors are connected in series.

20. A method of filtering aquarium water comprising the steps of:

Providing one or more reactor vessels connected to a zoned plenum, wherein reactors may be arranged independently or in series, wherein each reactor receives hydrological supply; drain; and/or recirculation through same plenum.

21. The method of claim 20 wherein said one or more reactor vessels is provided with filter media contained within said housing.

22. The method of claim 20 wherein the one or more reactor vessels provide foam fractionation, mechanical filtration, biological filtration, chemical filtration, nitrate reduction, phosphate reduction, carbon dioxide saturation, calcium ion supplementation, algae based filtration, and/or micro-fauna production.

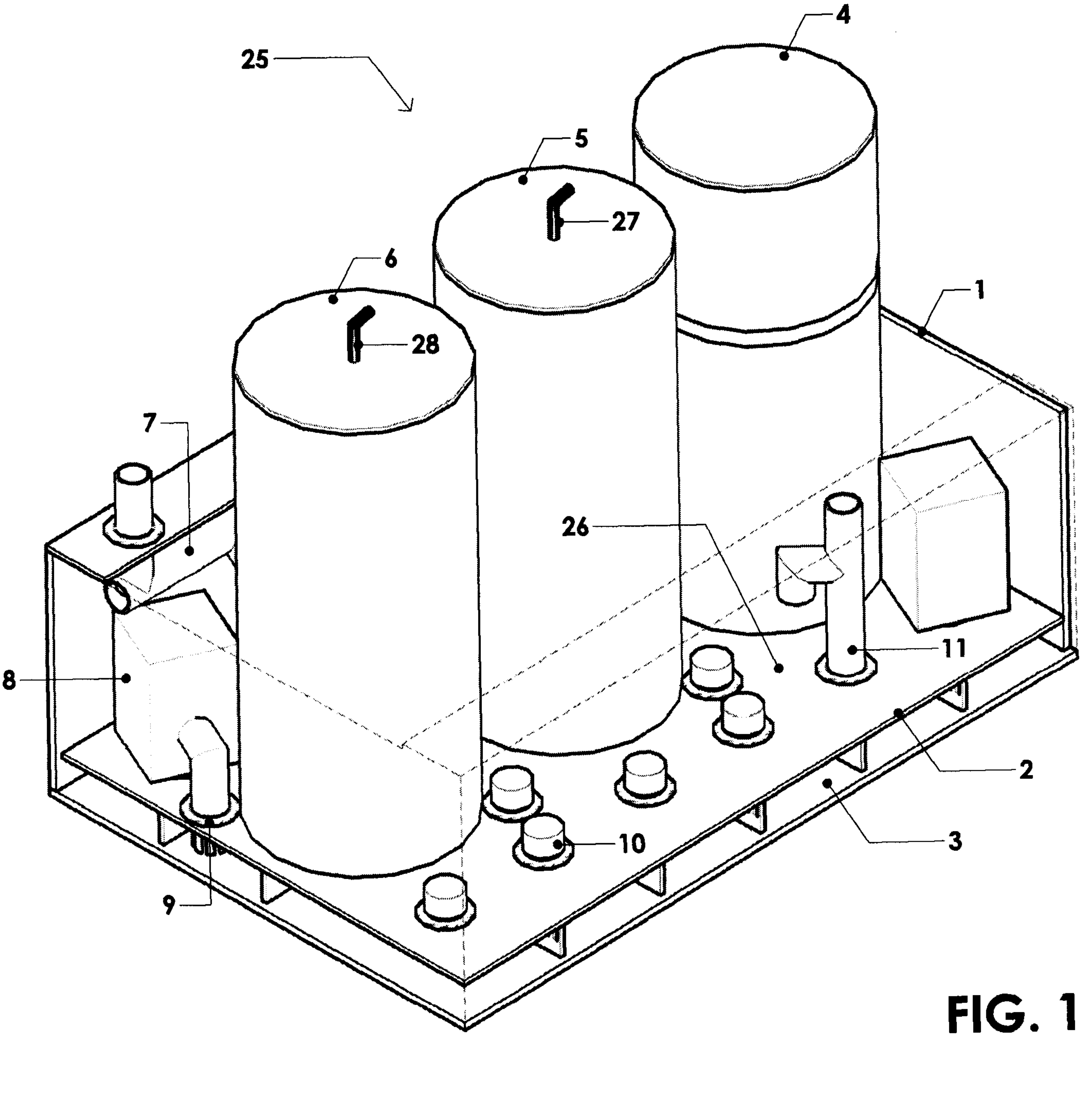

FIG. 1

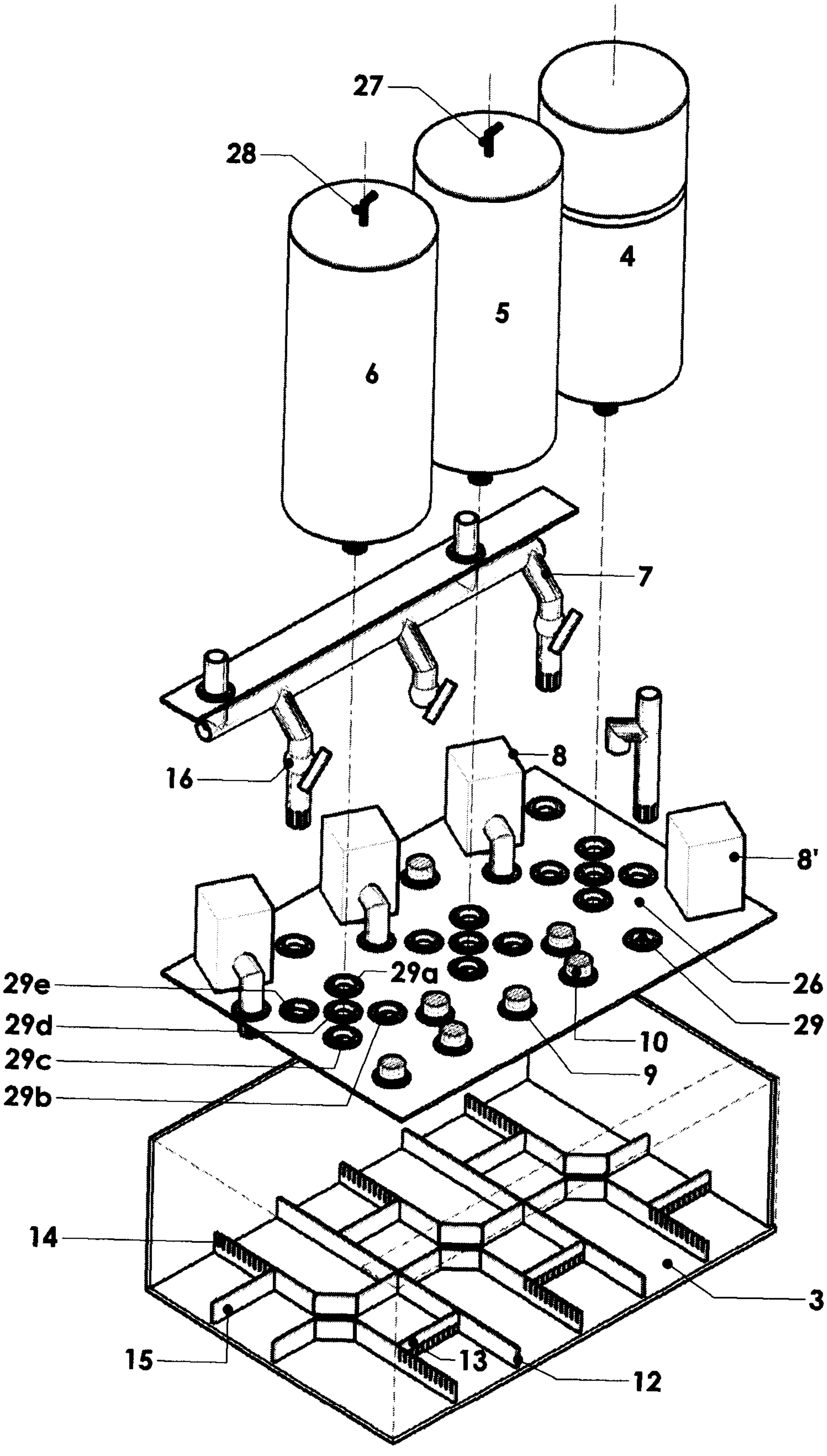

FIG. 2

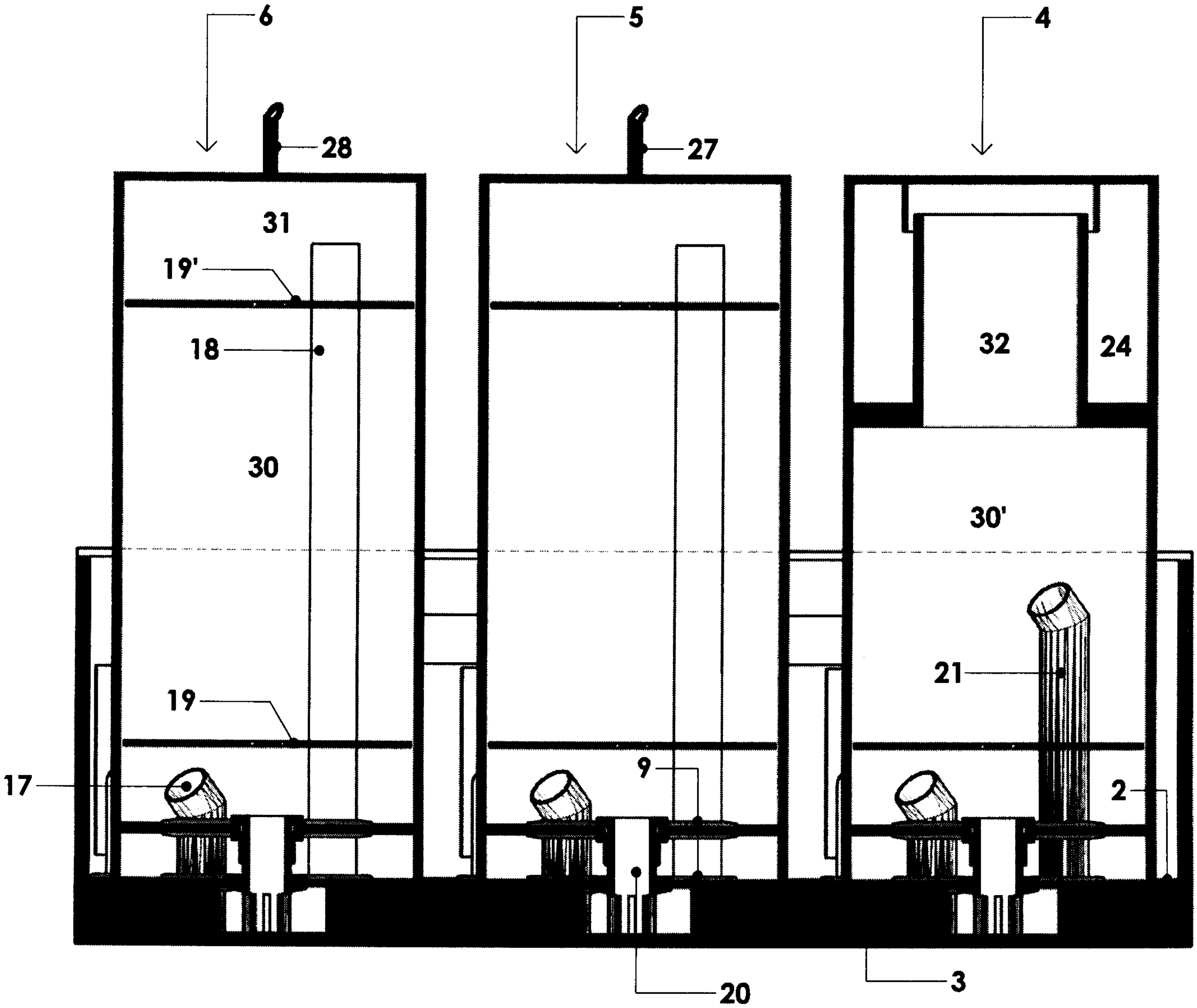

FIG. 3

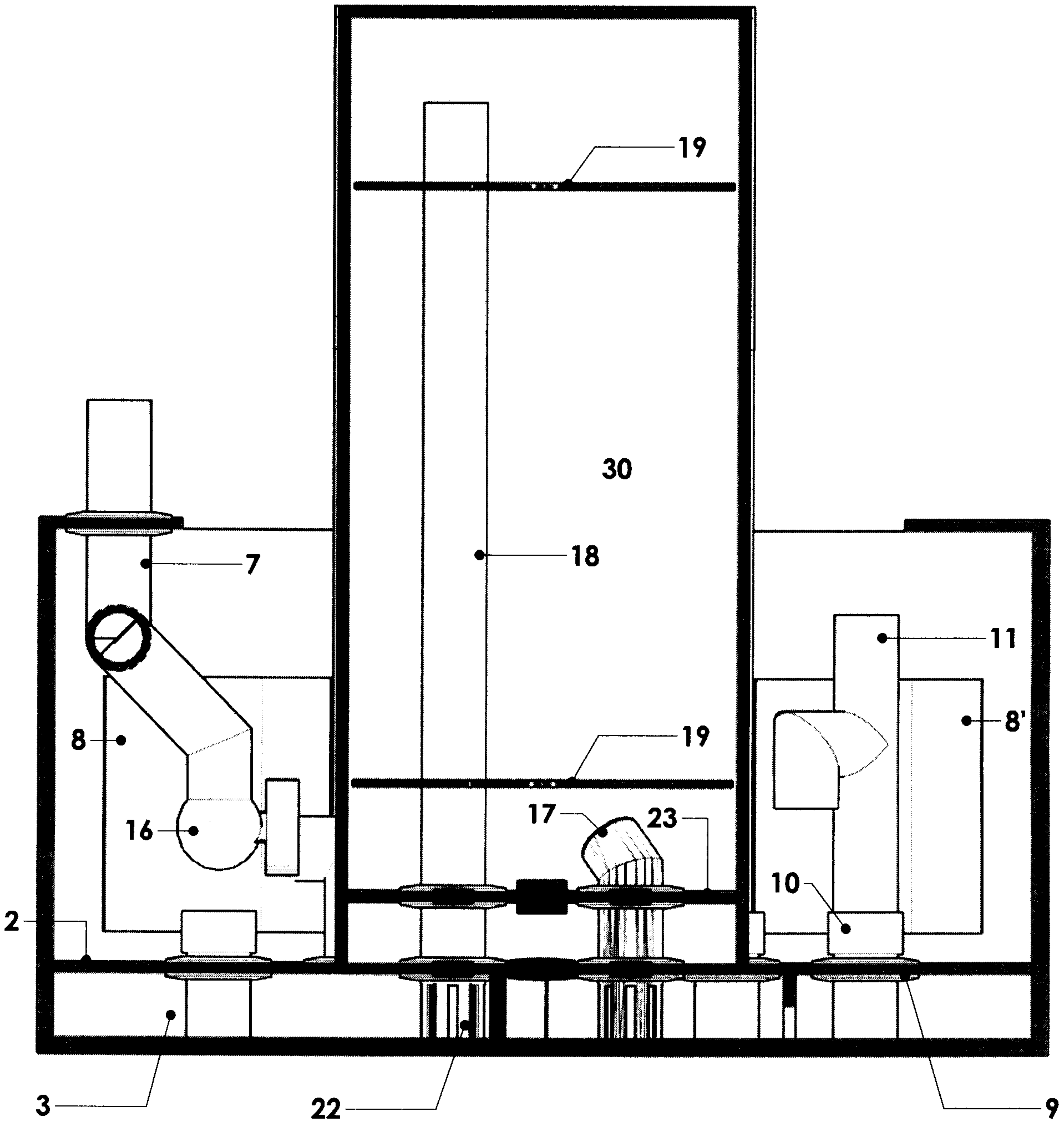

FIG. 4

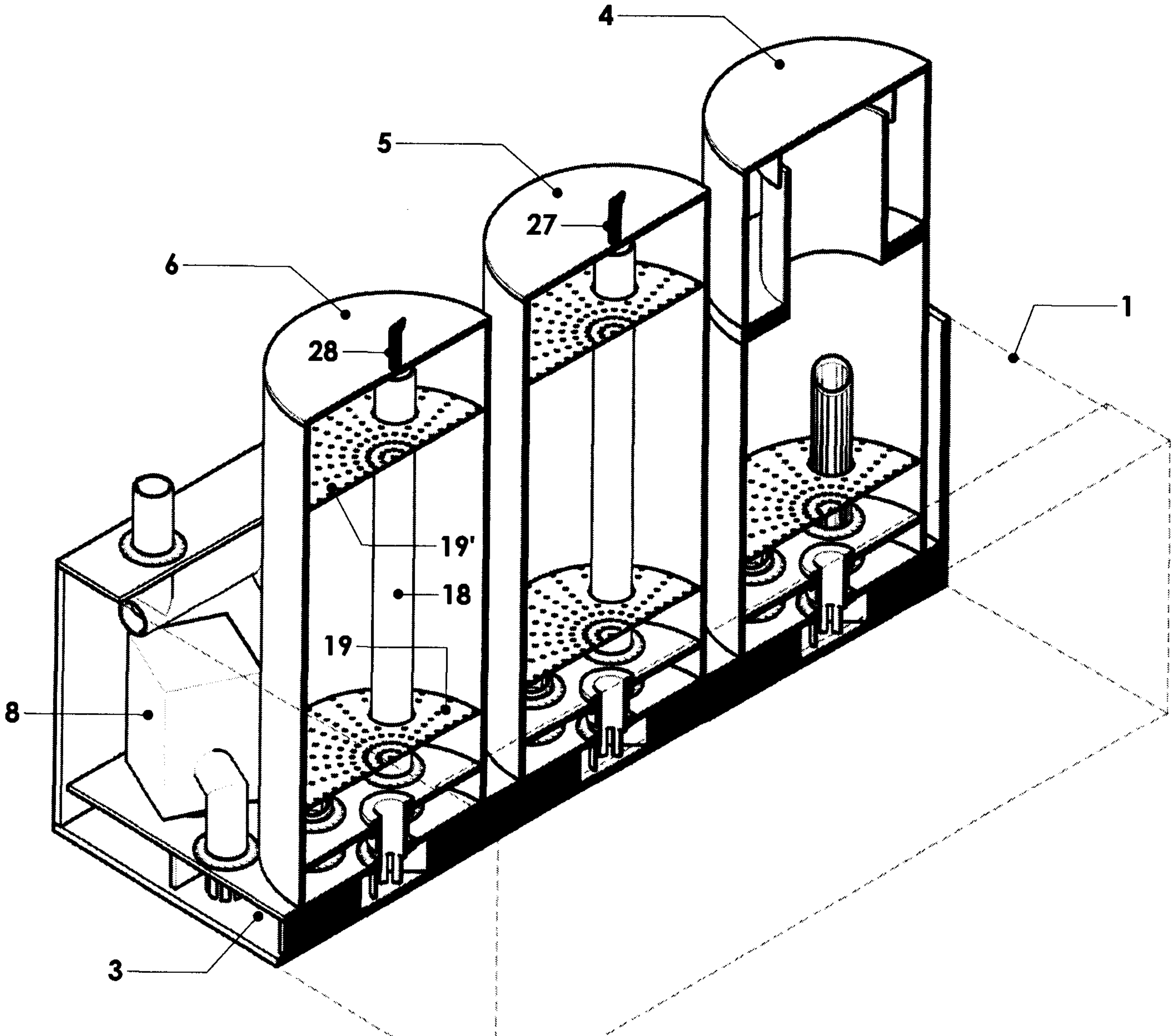

FIG. 5

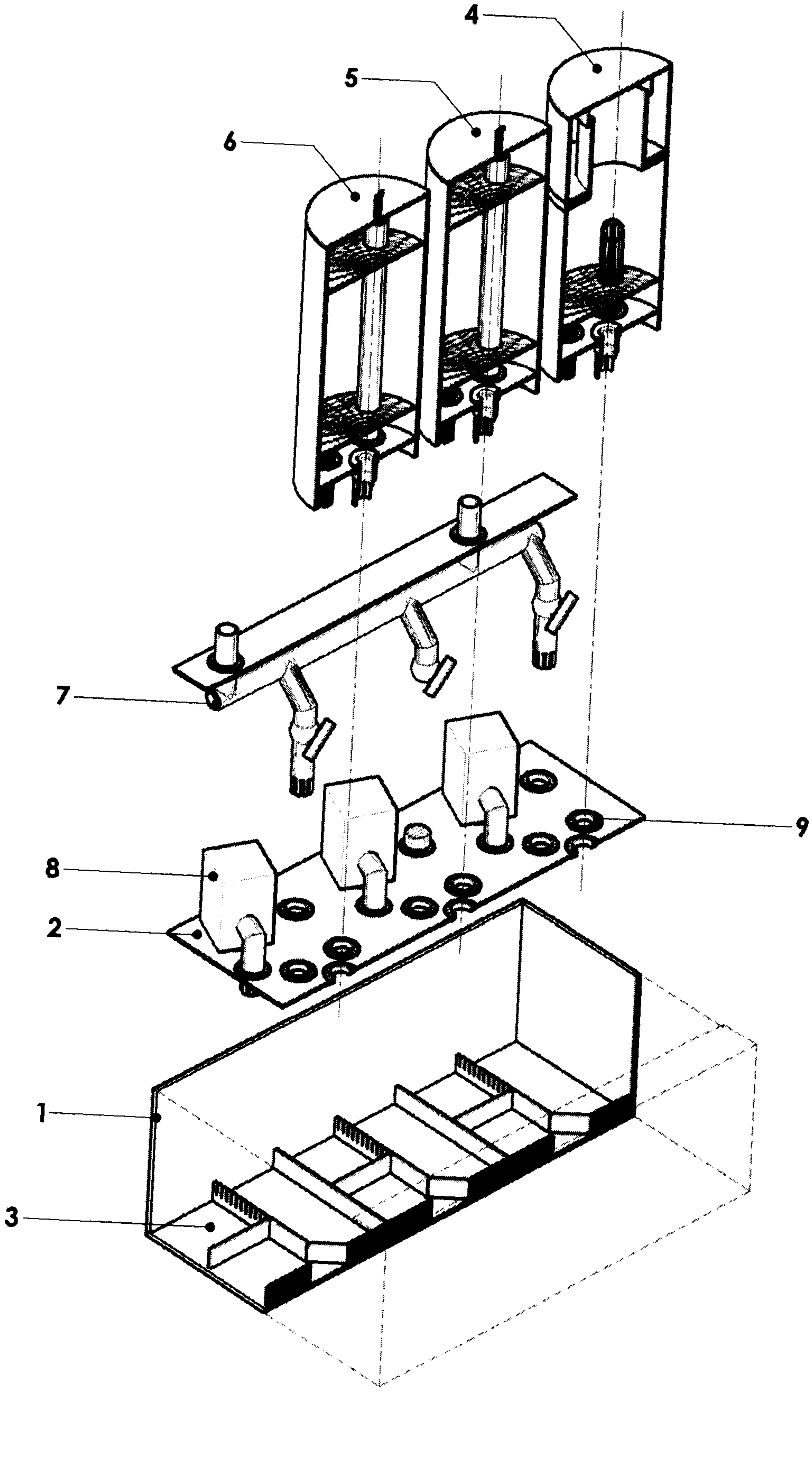

FIG. 6

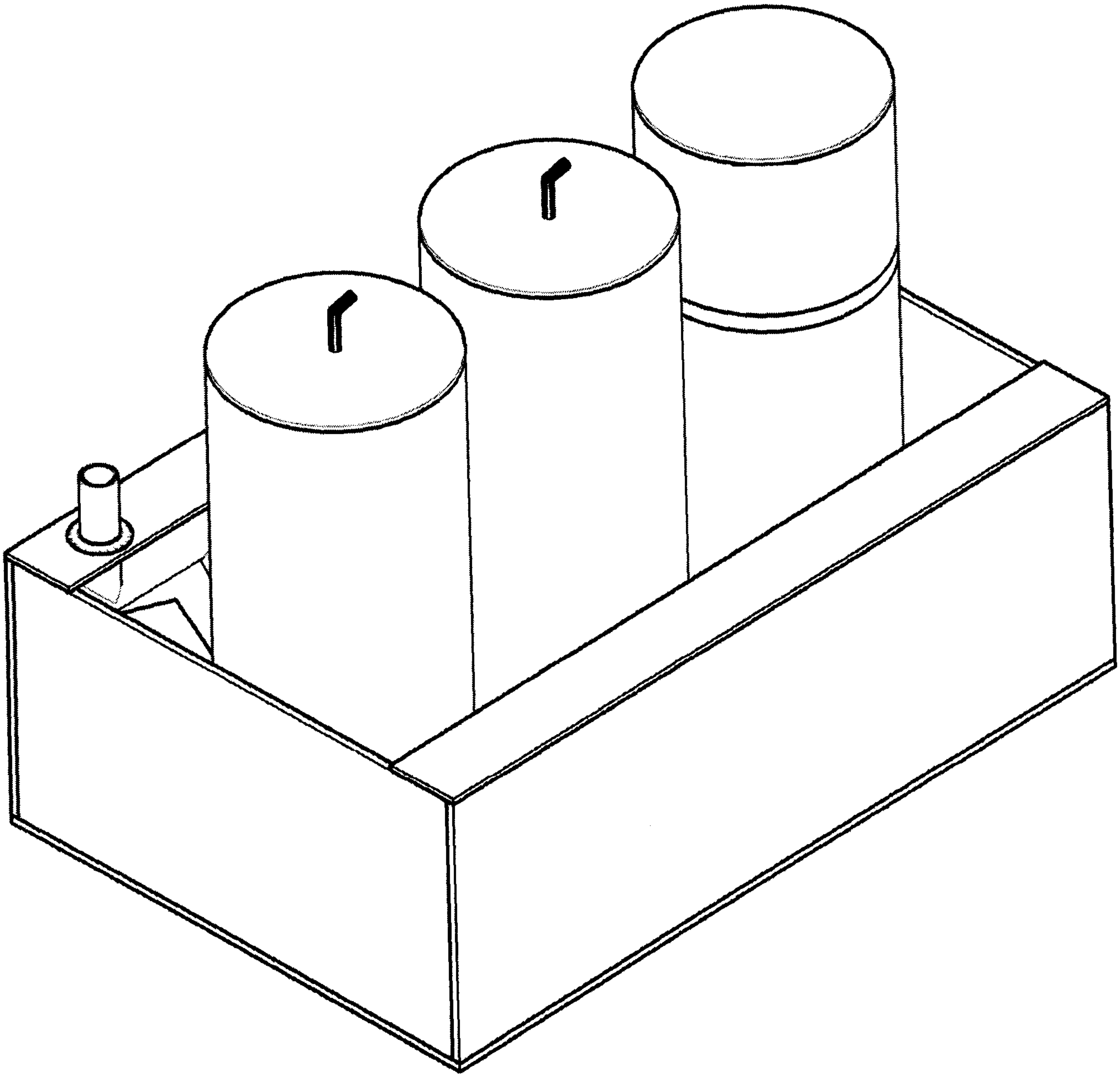

FIG. 7