US 20090071472A1

(19) **United States**

(12) **Patent Application Publication**

Cohen et al.

(10) **Pub. No.: US 2009/0071472 A1**

(43) **Pub. Date: Mar. 19, 2009**

(54) **APPARATUS FOR PRODUCING OXYGEN AND/OR HYDROGEN GAS**

(76) Inventors: **Binyomin A. Cohen**, Brooklyn, NY (US); **Shalom B. Drizin**, Brooklyn, NY (US); **Joel Zev Drizin**, Brooklyn, NY (US); **Moshe Drizin**, Brooklyn, NY (US)

Correspondence Address:
DILWORTH & BARRESE, LLP
333 EARLE OVINGTON BLVD., SUITE 702
UNIONDALE, NY 11553 (US)

(21) Appl. No.: **12/231,811**

(22) Filed: **Sep. 5, 2008**

Related U.S. Application Data

(60) Provisional application No. 60/967,756, filed on Sep. 7, 2007.

Publication Classification

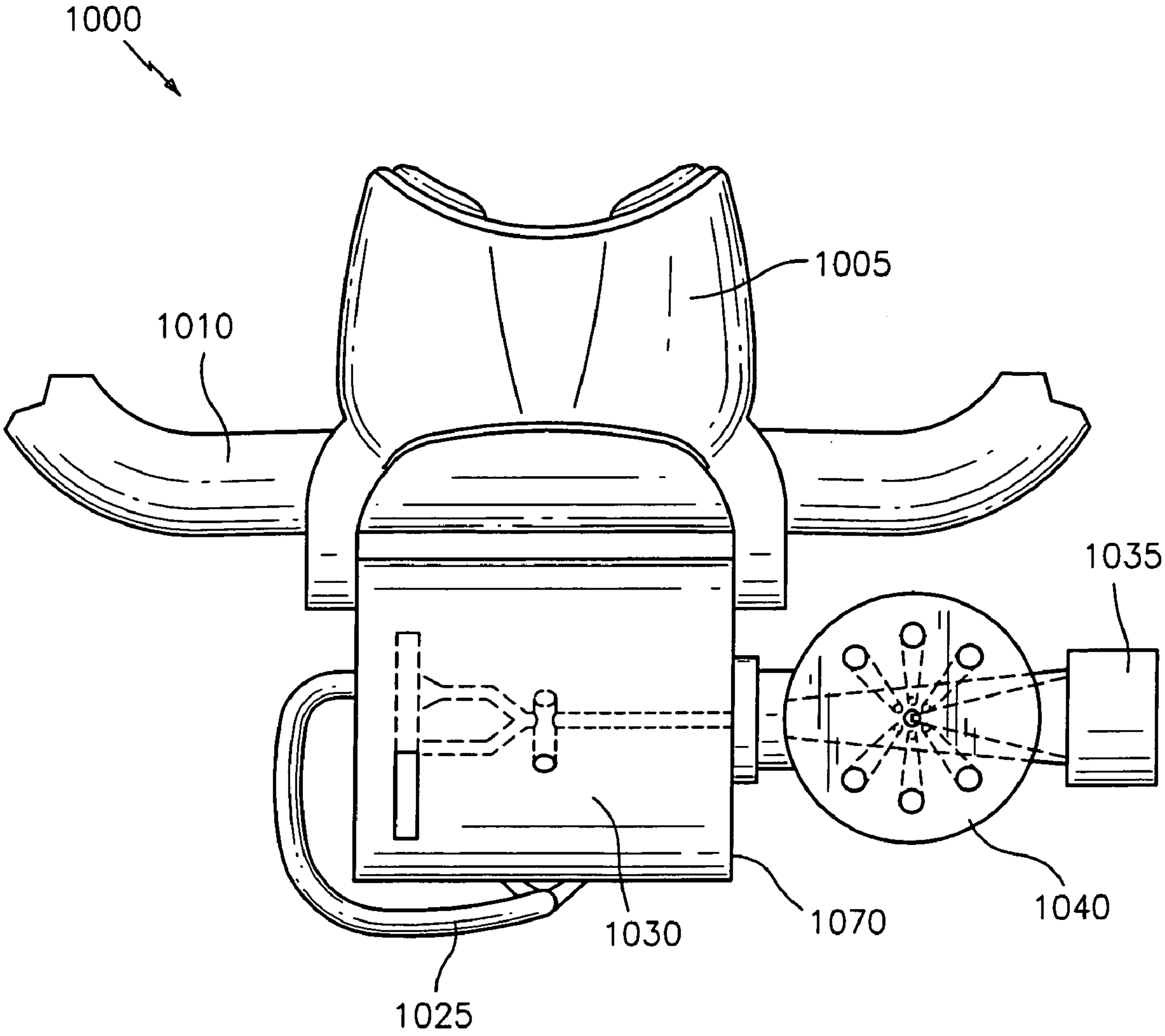
(51) **Int. Cl.**

A62B 7/08	(2006.01)
B01J 19/00	(2006.01)

(52) **U.S. Cl.** **128/202.26**; 422/222

(57) **ABSTRACT**

An apparatus for providing oxygen and/or hydrogen by splitting water and filtering out oxygen from exhaled air, atmospheric air, and/or air from a fan motor using an alternating repeating catalytic and filtering screens with the first screen in the repeating unit having diRuthenium and second screen having Zeolite crystalline bodies.



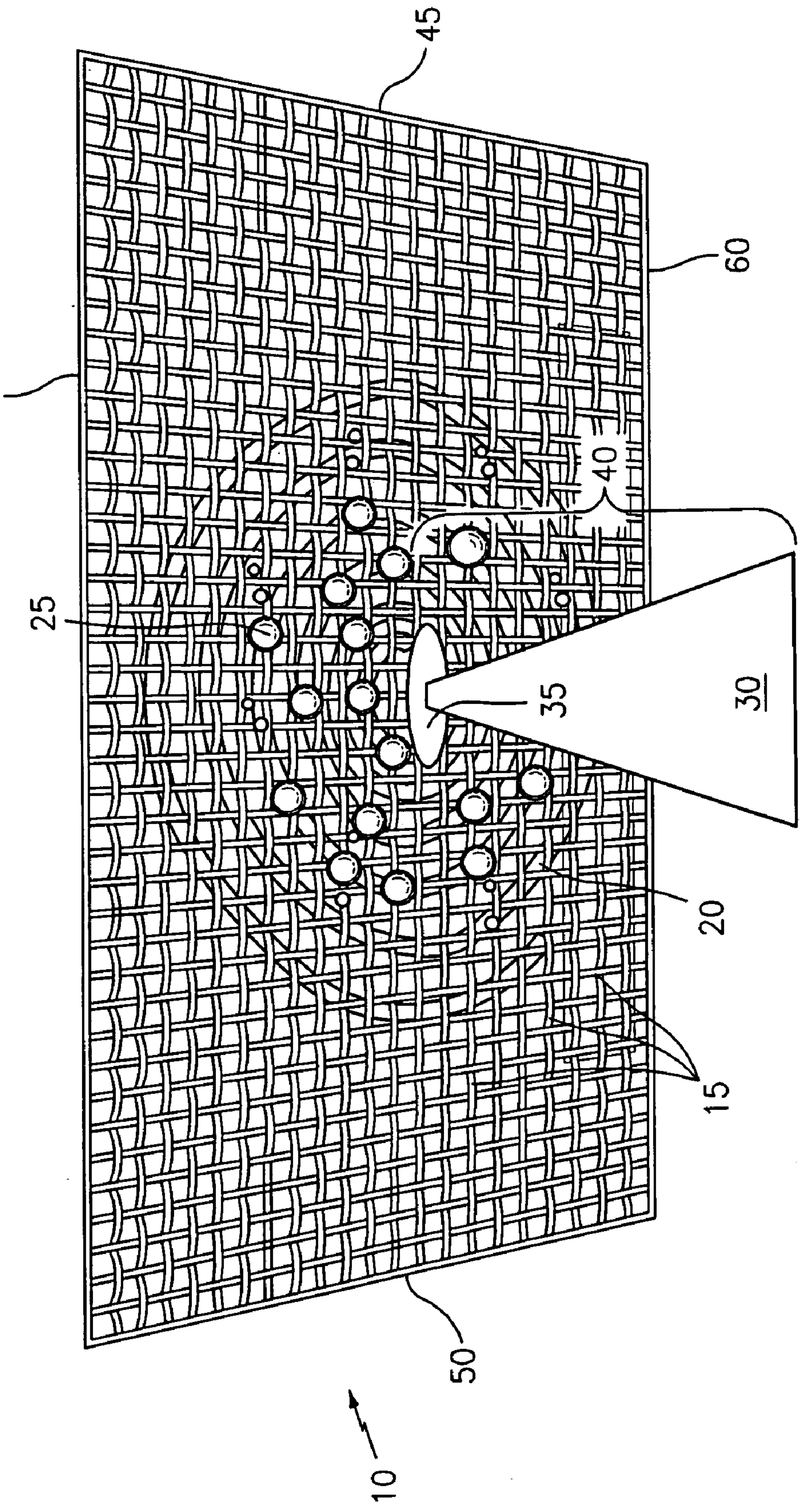


FIG. 1

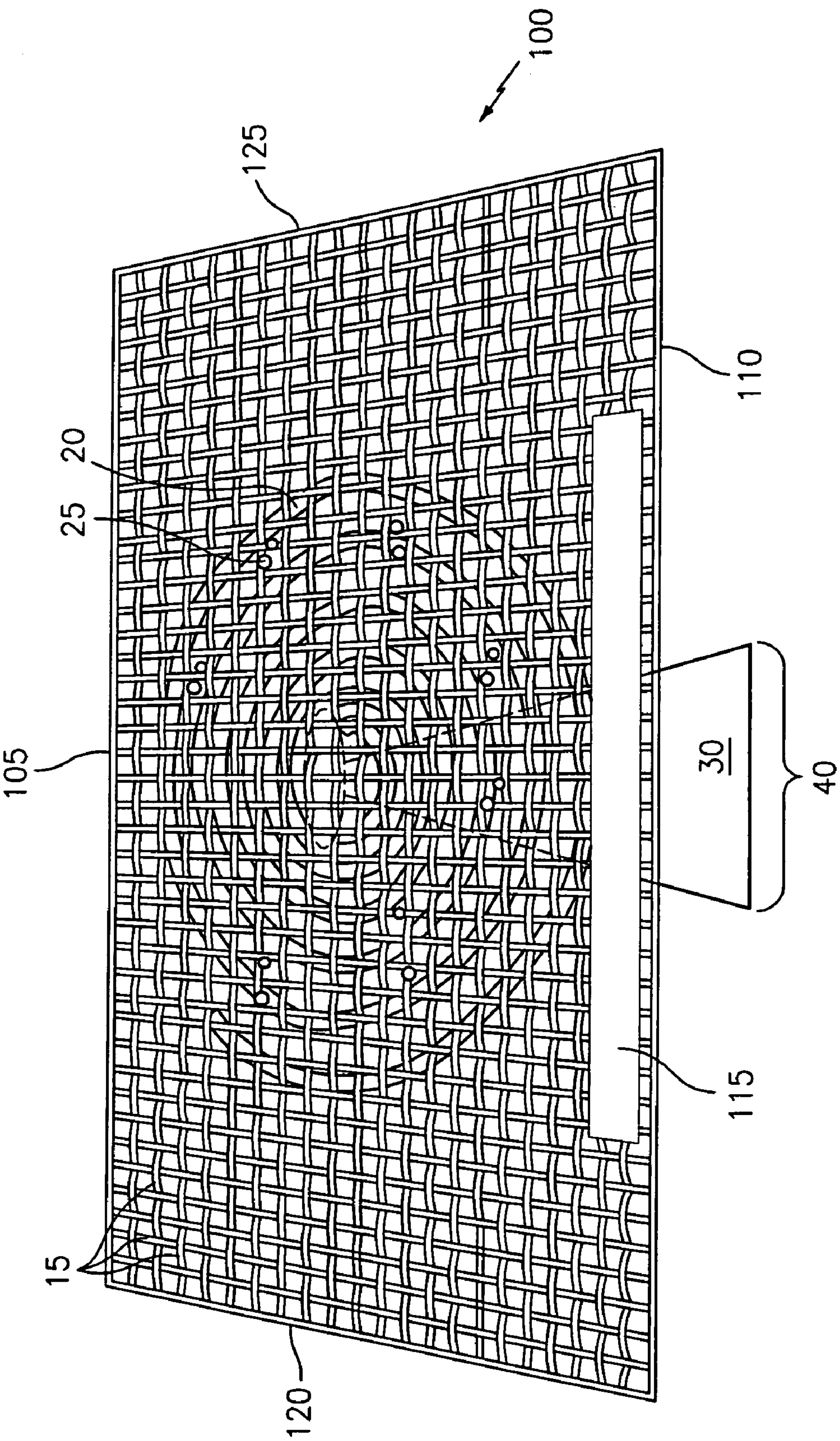


FIG. 2

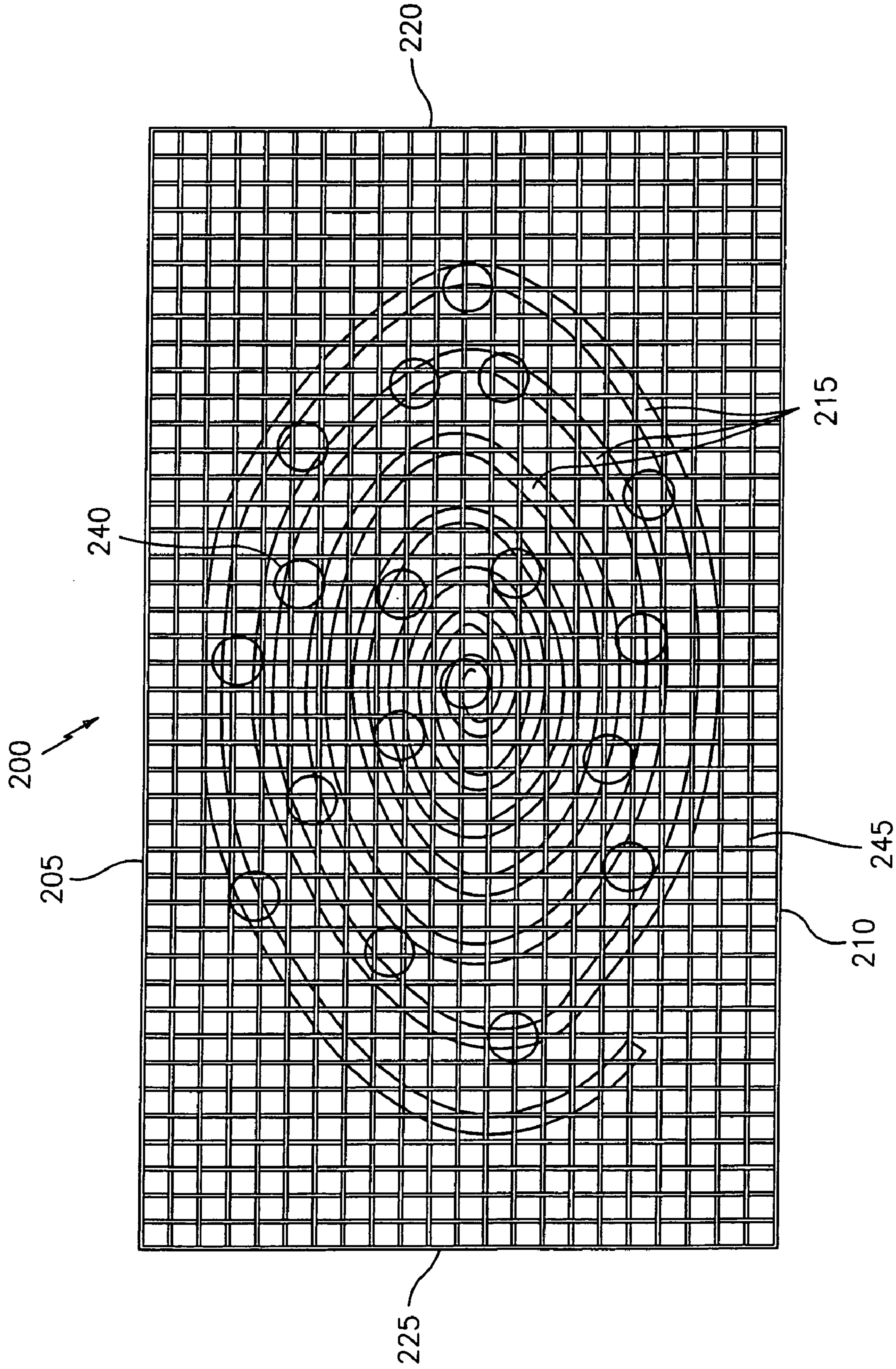


FIG. 3

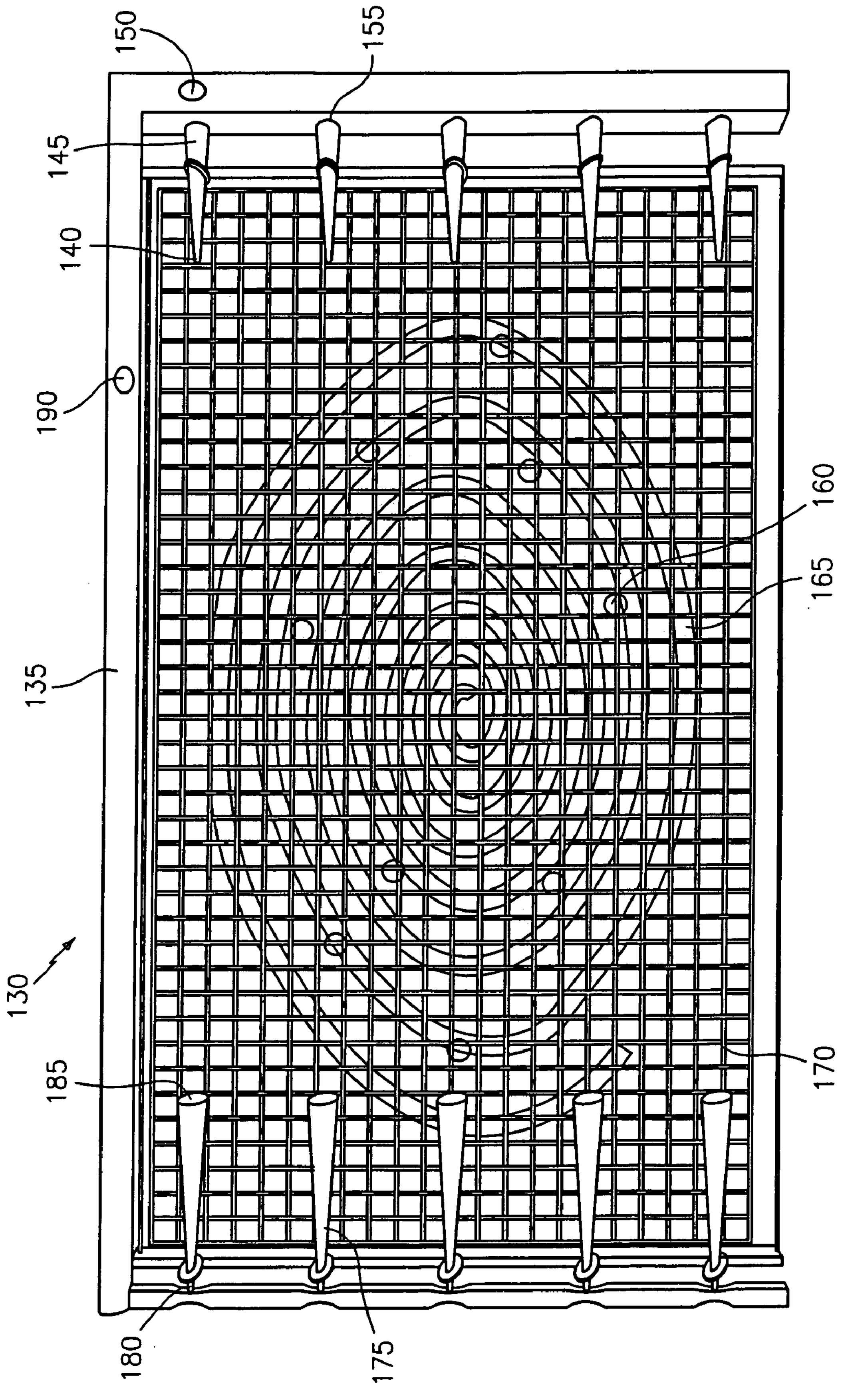


FIG. 4

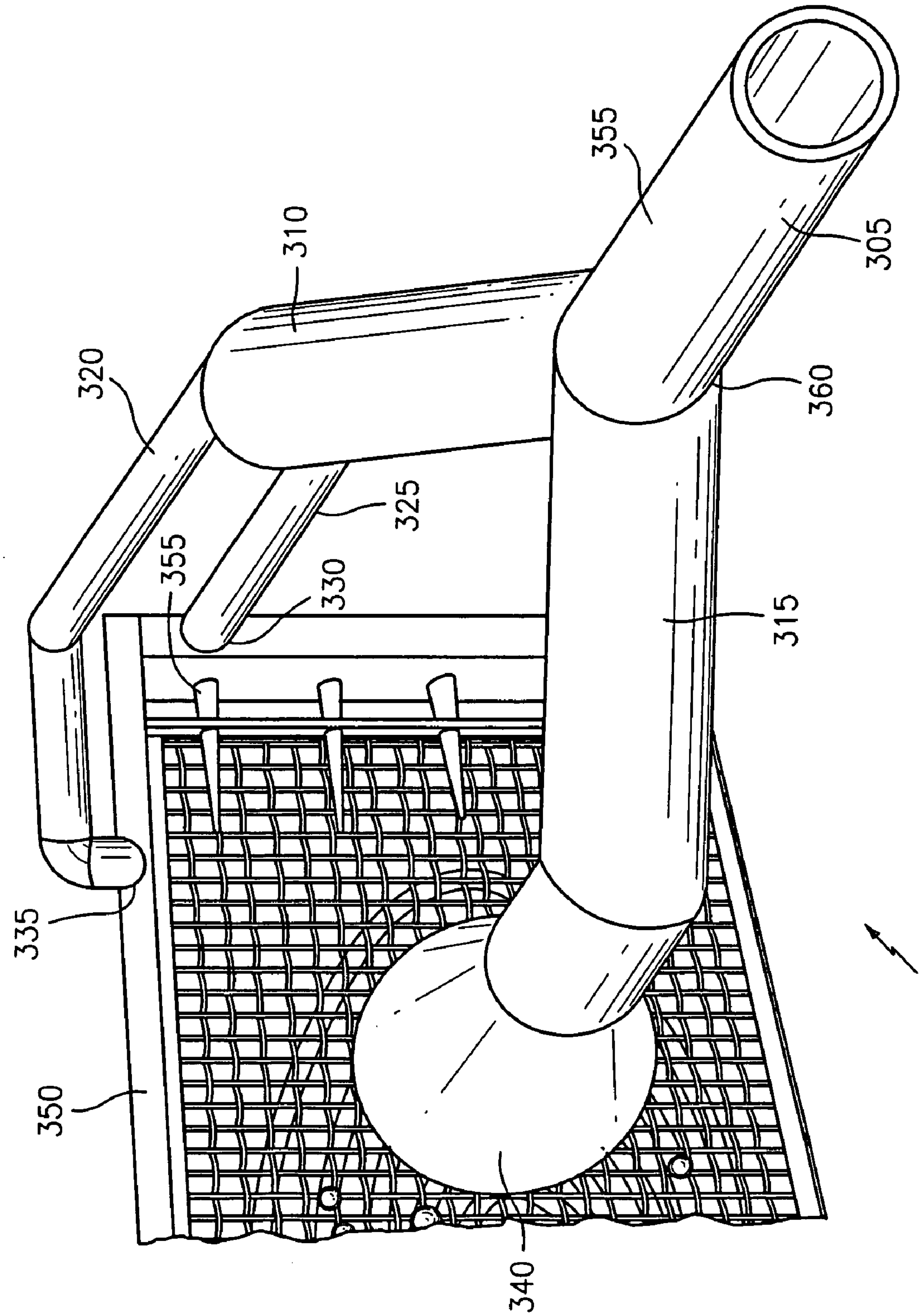


FIG. 5

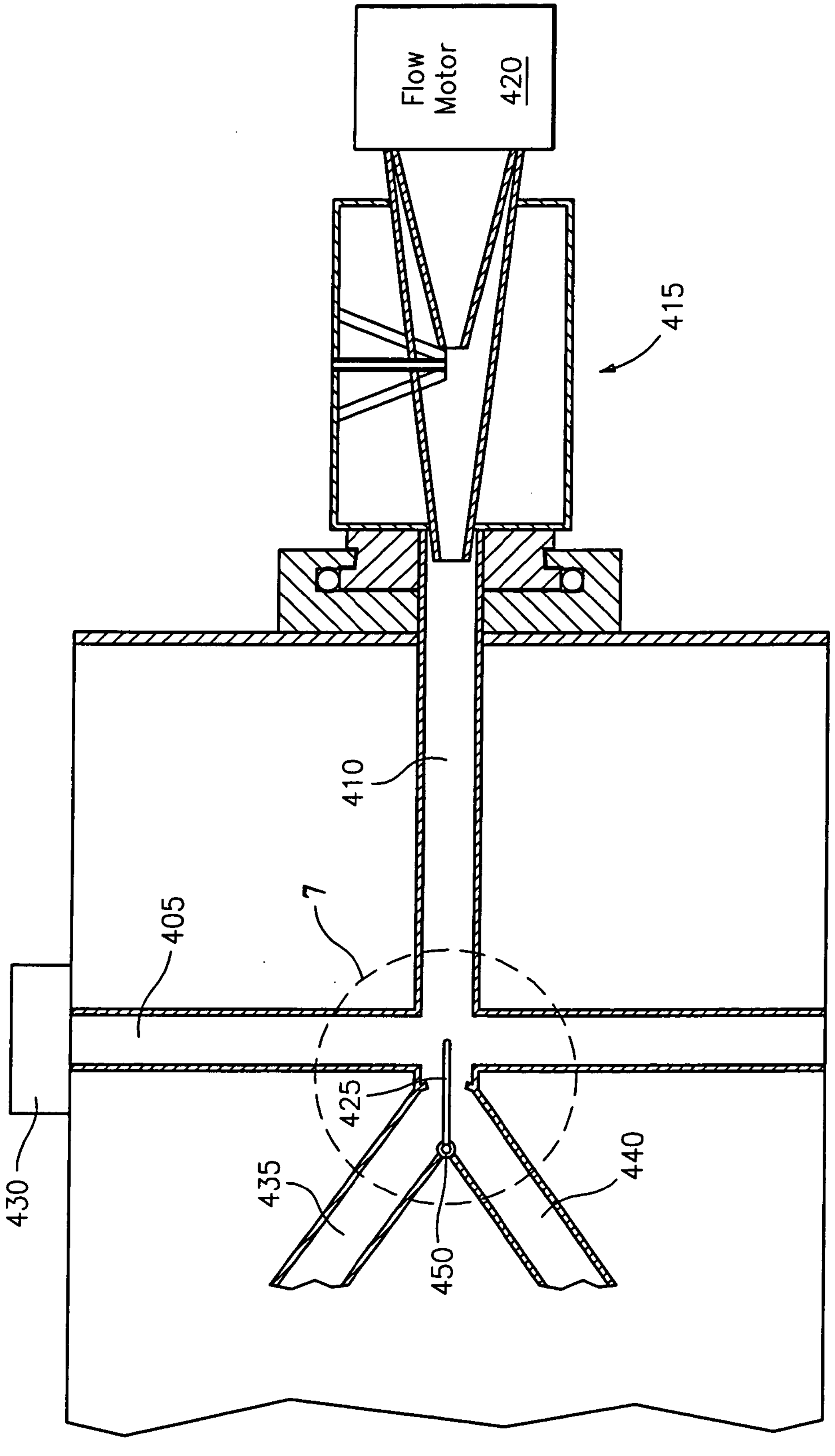


FIG. 6

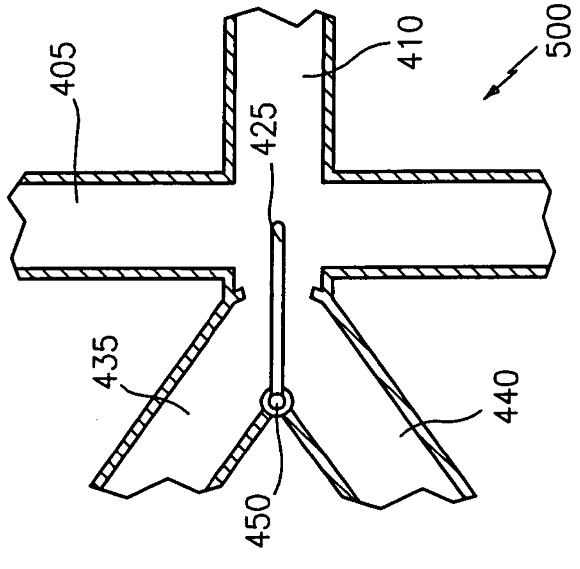


FIG. 7A

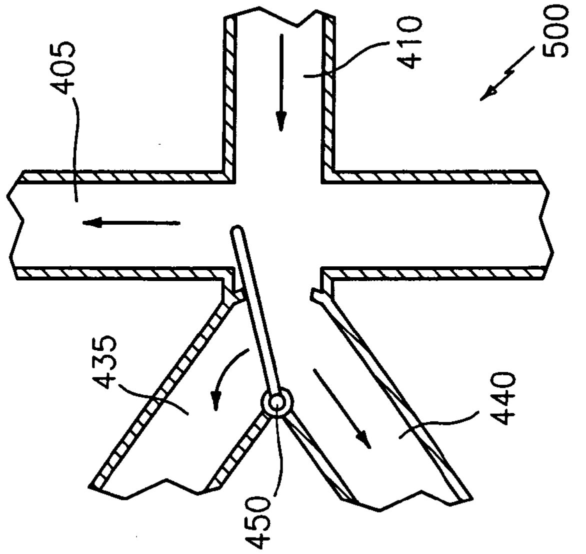


FIG. 7B

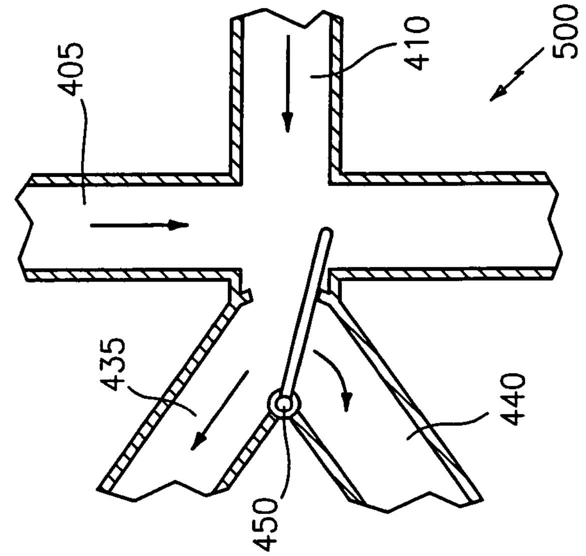


FIG. 7C

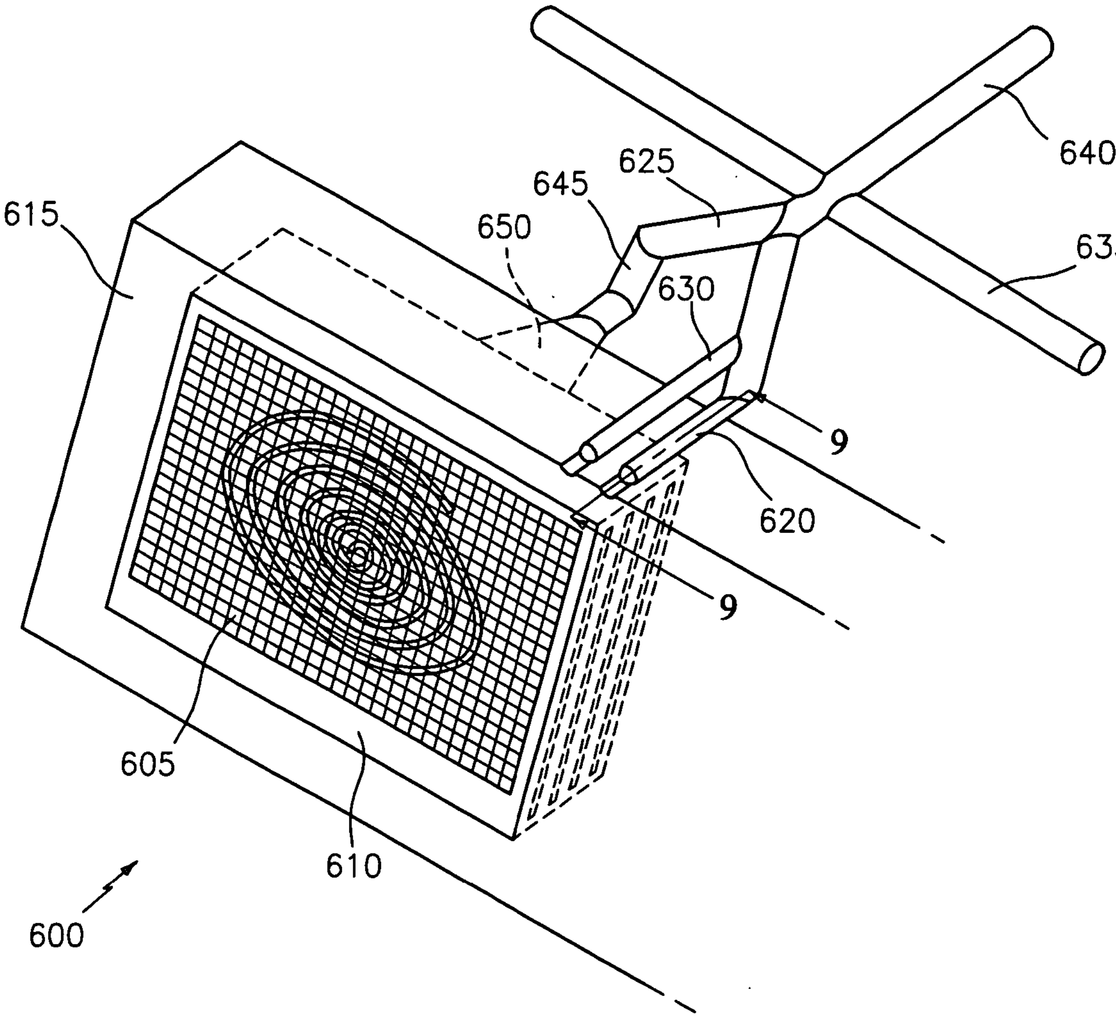


FIG. 8

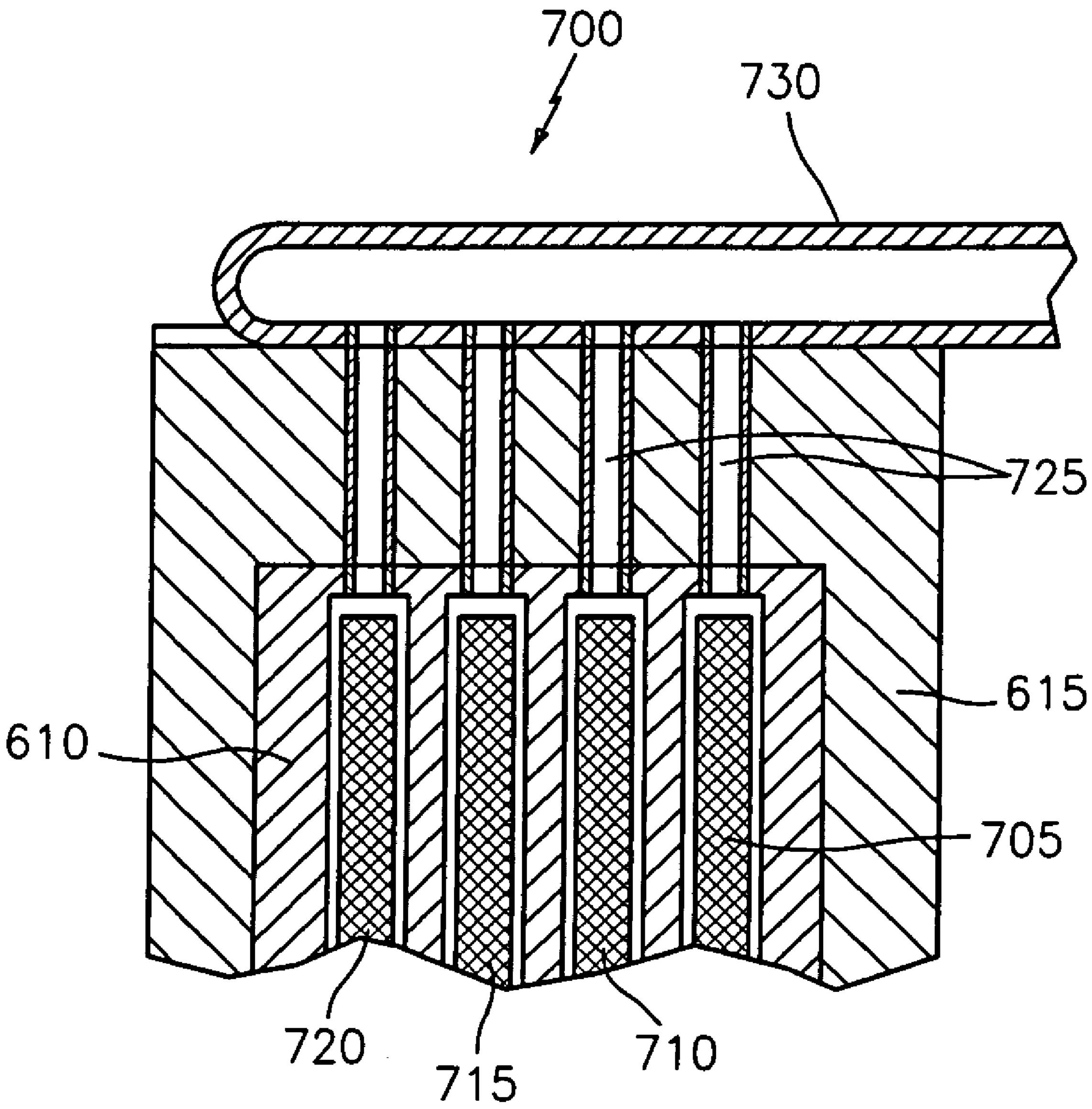


FIG. 9

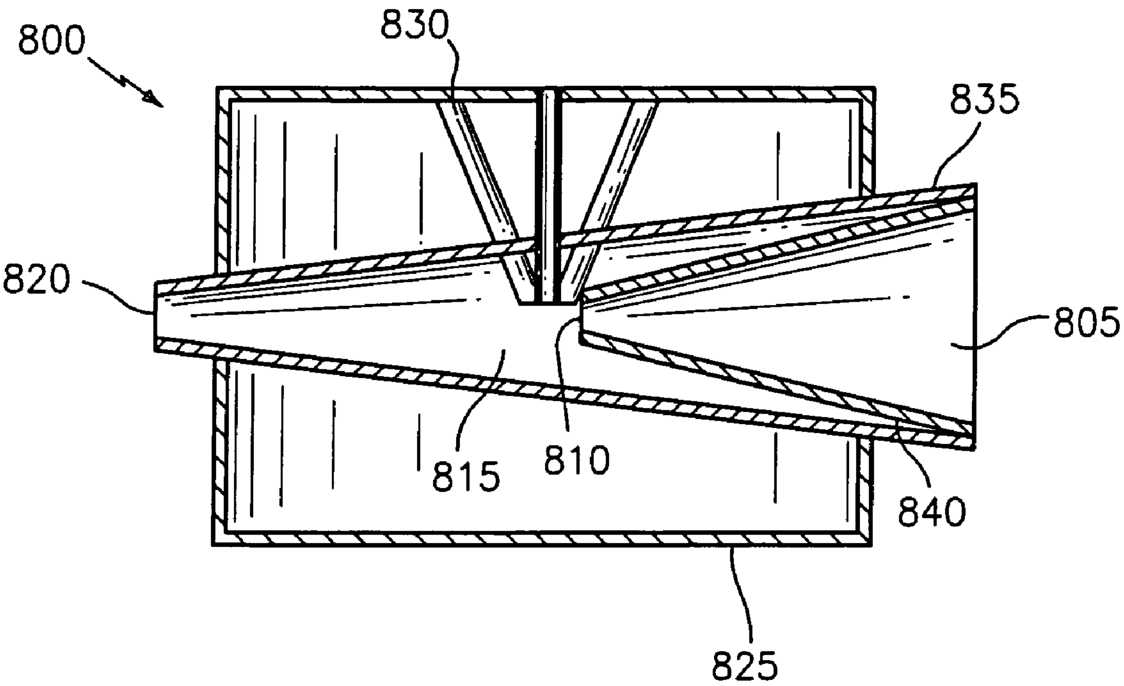


FIG. 10

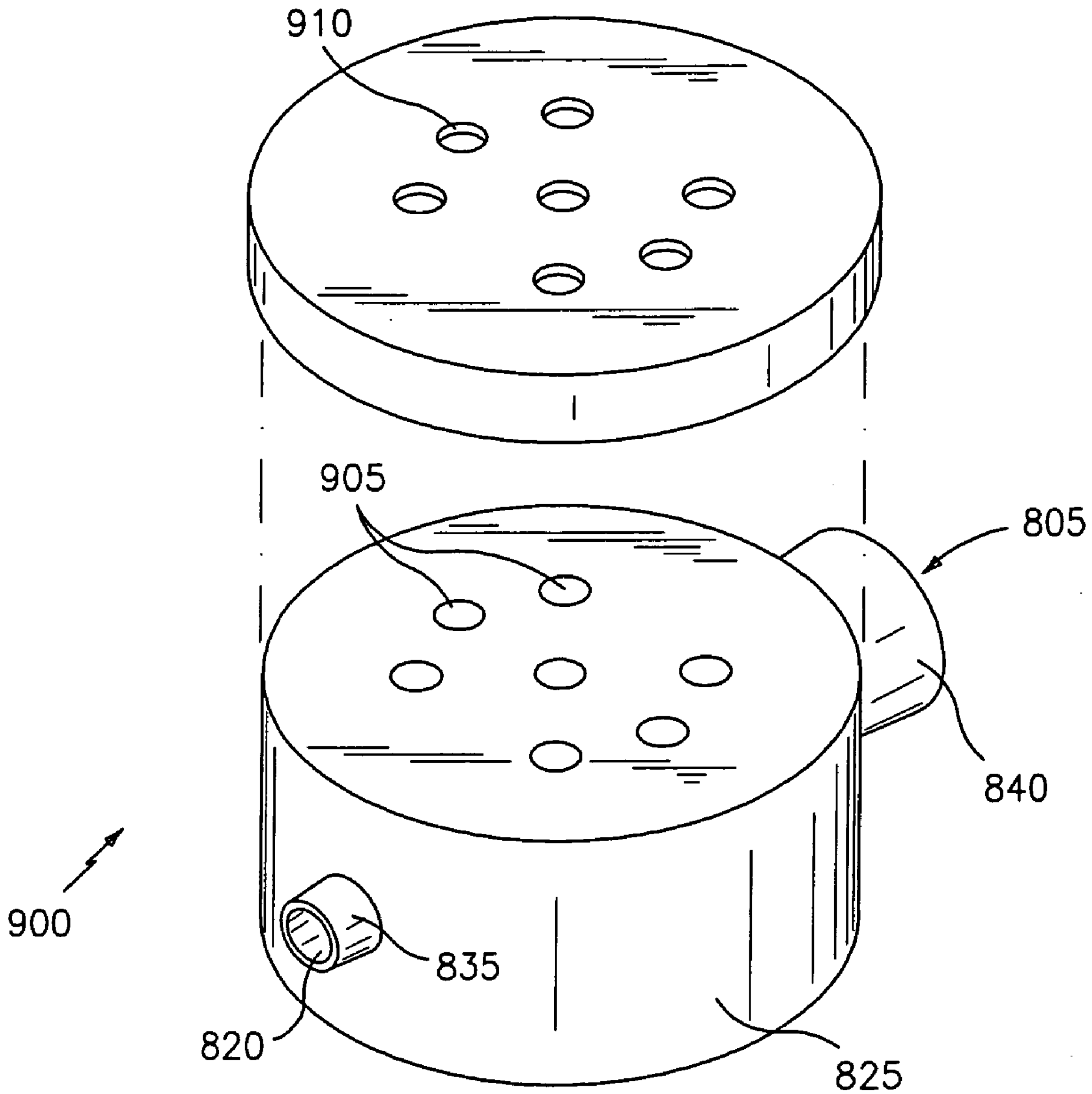


FIG. 11

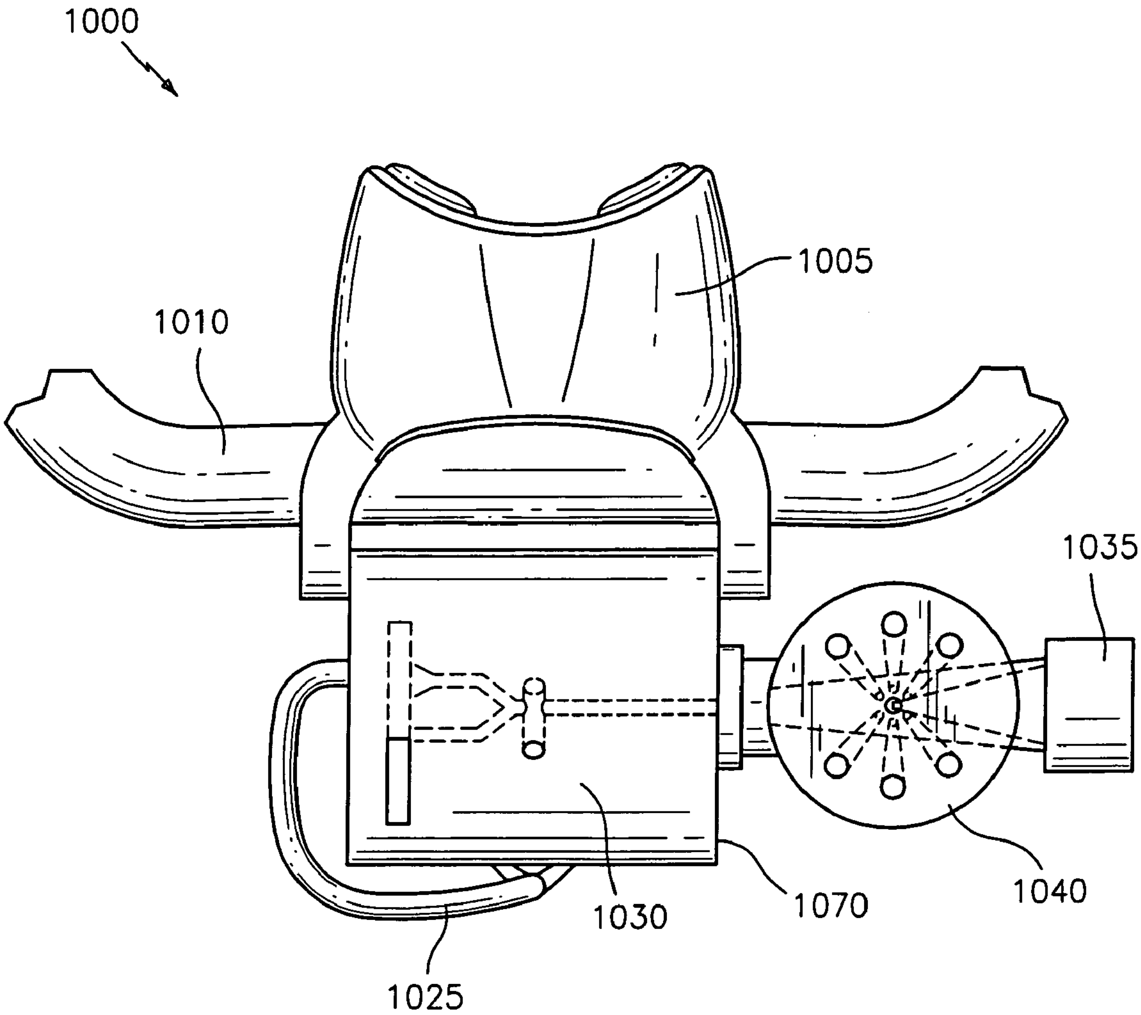


FIG. 12

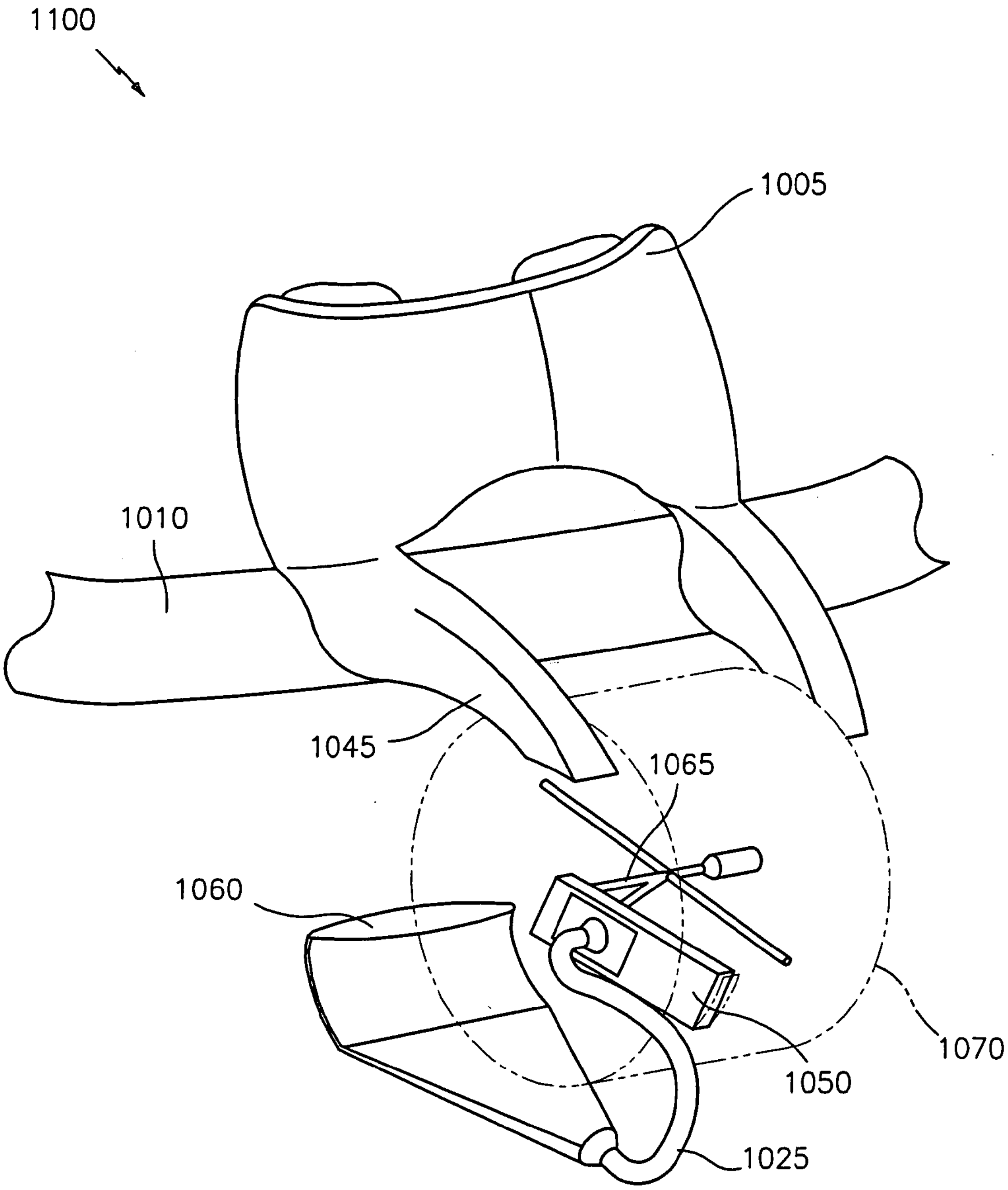


FIG. 13

APPARATUS FOR PRODUCING OXYGEN AND/OR HYDROGEN GAS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application Ser. No. 60/967,756 filed Sep. 7, 2007, which is herein incorporated by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to oxygen and/or hydrogen generating apparatuses and in particular, but not exclusively, to oxygen generating apparatuses for generating breathable oxygen from water, exhaled air and/or room humidity using a filter material. The filter material containing at least one diRuthenium/diRuthenium complex affixed to a Boron doped carbon film and a synthetic film containing zeolite crystalline. The filter material of the present invention provides not only a high separation efficiency due to the use of the diRuthenium/diRuthenium complex, but also provides additional separation efficiency by coupling the catalyst properties of zeolite to the high separation efficiency of the diRuthenium/diRuthenium complex.

BACKGROUND OF THE INVENTION

[0003] The present invention relates in general to an oxygen-generating apparatus and in particular to a new and useful respirator which includes a cartridge comprising a filter material for liberating oxygen from water, exhaled air vapor and ambient humidity. The filter material of the present invention is arranged in the apparatus so that the respiration path of air flows into and over the filter material and oxygen generated by the filter material flows back into the inhalation pathway of the patient. Oxygen generating devices using chemicals and filters are not new but suffer from several shortcomings. Respirators available on the market today often require large machinery, including pressurized chambers, supply oxygen, heat transformers etc. in order to work and therefore are not truly portable. In particular, apparatuses that use the Pressure Swing Adsorption Cycles ("PSA") method described in U.S. Pat. No. 2,944,627, which is herein incorporated by reference, require pressurized chambers. In a PSA system oxygen is produced by the selective adsorption of nitrogen from a feed air stream. The PSA has at least one, often two adsorbent beds, which are designed to attract oxygen gases at low pressures and release the adsorbed oxygen at higher pressures. The PSA processes can be used to separate gases in a mixture because certain gases tend to be attracted to and or adsorbed by different solid surfaces more or less strongly than others.

[0004] Another Oxygen generation process that can be used to generate oxygen for respiration uses some of the principals of the PSA process and is called the Vacuum Swing Adsorption (VSA). In a "VSA" process, gases are separated using pressure but unlike the PSA process it is done at lower absolute pressures. Although these methods do work, they require multiple pressurized vessels and electronic valve systems making portability difficult if not impossible. That is, these systems require valve operations either done automatically or by carefully calculated timing cycles often controlled by a PLC. Accordingly, these systems are quite large and therefore prevent a patient from either directly wearing oxygen-generating system or being a truly portable system in addition to not being tied to the patient's breathing pattern.

[0005] Over the years, improvements to the PSA and VSA systems were made such as in U.S. Pat. No. 3,313,091, incorporated herein by reference. While the earlier PSA and VSA systems used crossover valving and Zeolite adsorbing material to produce a product high in Oxygen purity, these systems were neither consistent nor simple. To maintain consistent oxygen production, U.S. Pat. No. 3,313,091 used a vacuum pump to draw part of the adsorbed termed "waste gases" from the vessel or bed being purged. These advancements over the earlier PSA and VSA systems however, required even more complex electromechanical design additions including added phase controlling, e.g. gas entry, vacuuming re-pressurization and dumping to allow Oxygen gas as a product of several cycles to transfer through and out to a user or patient did provide a higher yield but only at low flows, typically less than about 6 lpm.

[0006] The next advancement in oxygen filtration/generation came in 1980 and was described in U.S. Pat. No. 4,222,750, which is herein incorporated by reference. In this patent, the vessels or beds of adsorbing filtration materials cyclically underwent both periods of adsorption in which said vessel or bed received gas from a compressor then reabsorbed from the beds using a vacuum pump. As one can see, this improvement added even more equipment to the systems making it even less likely to be used as a portable system.

[0007] Therefore, what is needed in the market today is an oxygen generating apparatus that uses filters that can be used without pressurized chambers/valves and other large equipment that can generate sufficient amounts of oxygen to be used in either a portable breathing device or a fixed supply system. That is, an apparatus wherein the filter material used to produce oxygen at a rate and concentration necessary to maintain breathing in a patient without pressurizing and depressurizing chambers, and/or opening and closely complex valve systems. The present invention provides an oxygen generating apparatus that overcomes the shortcomings of the prior art while also able to be used as a truly portable oxygen generating system capable of maintaining proper oxygen levels necessary for breathing by a patient or used in industrial situations. The present invention is discussed in the section below.

SUMMARY OF THE INVENTION

[0008] One object of the present invention is to provide a breathing device that is a truly portable oxygen generating apparatus that does not require pressurized chambers. That is, the present invention provides an apparatus for producing oxygen and/or hydrogen gas from a source comprising a tubular and solid frame having an area configured to accommodate a cartridge. The cartridge configured to accommodate a filter material comprising a plurality of repeating units designed to chemically split water into bimolecular oxygen and hydrogen for breathing and hydrogen for possible energy uses. The repeating unit includes two screens having two different types of materials. The first material being an electro-generating catalyst encased in a frame to produce a screen comprises a porous boron doped carbon film with diRuthenium/diRuthenium molecules and at least one type of electronegative ion(s) that are position so as to be in direct contact with the porous boron doped carbon film. The porous boron doped carbon film further comprises an embedded nanocarbon tubular mesh network into said porous boron doped carbon film and a Ruthenium ion capturing siderophore plate that is connected to the opposite surface of the porous boron doped carbon film to which the diRuthenium/diRuthenium molecule is attached. Since free Ruthenium ions are dangerous to the person breathing from the apparatus, the ionically charged siderophore plate is designed to capture free Ruthenium ions that may become dislodged from the porous boron doped carbon film during use.

[0009] The second screen of the repeating unit comprises in a frame encasing an ultra filtration zeolite containing synthetic film. The second screen is positioned directly behind the first screen and makes up one repeating unit. The apparatus of the present invention can contain between about 3 to about 100 repeating units or more depending on whether the apparatus is being used for one patient, multiple patients, airline air supplies, room oxygenating devise, for fuel cells, or storage of oxygen and/or hydrogen. The second screen synthetic film comprises a plurality of nanocarbon tubules attached and/or embedded to/on a surface of the synthetic film to form a nanocarbon tubule mesh network. At least one zeolite crystalline body is in direct contact with the nanocarbon tubules wherein the synthetic film comprises a multiplicity of pores each having a diameter of about 0.1 to about 3.0 nm and the zeolite crystalline bodies attached to the nanocarbon tubules overlap at least part of the pores. The synthetic film is positioned proximal to the surface of the porous boron doped carbon film comprising the siderophore.

[0010] The apparatus for producing oxygen and/or hydrogen gas may contain several repeating units, a miniature fan motor, a mouthpiece and a flow booster. The mouthpiece is connected to the apparatus so that airflow form the fan motor along with exhaled air can travel over the first and second filters to produce bimolecular oxygen. The flow booster has a first and second nozzle positioned within each other and within an enclosure. The first and second nozzles are open at both ends and have a wide end tapering to a narrower end, wherein the wide end of the first and second nozzles are in communication with a miniature fan motor. The enclosure of the flow booster configured to have a plurality of holes positioned directly above the first and second nozzles of the flow booster. These holes allow additional air into the flow booster due to the Venturi effect created as air exits the first nozzle into the second nozzle.

[0011] The apparatus for producing oxygen and/or hydrogen gas of the present invention further comprises a bi-furcated accelerator having a flap valve and at least two junctions. The flap valve is configured so as to pivot between a first and second position. When the flap valve is in the first position a first leg of the bi-furcated accelerator is closed and a second leg is open. When the flap valve is in the second position, the second leg of the bifurcated accelerator is closed and the first leg is open. This allows air to flow either to the screens or to the hollow frame of the screens from the flow booster or to be diverted by the flap valve in communication with the mouthpiece as controlled by the individual breathing pattern of the patient. In the alternative, the apparatus is configured that the flap valve can be locked in one position so as to obtain airflow for the filter material either directly from the flow booster or delivered form the mouthpiece exclusively. This flap valve can be unlocked at anytime so as to allow airflow from both the flow booster and the mouthpiece.

[0012] The present invention is also directed to a method for providing oxygen to a patient using the breathing device of the present invention.

[0013] The apparatus of the present device will be described in greater detail in the Detailed Description section in conjunction with the figures below.

BRIEF DESCRIPTION OF THE FIGURES

[0014] FIG. **1** shows a prospective view of the front surface of the porous boron doped carbon film comprising diRuthenium/diRuthenium molecules of the filter material of the present invention.

[0015] FIG. **2** shows a prospective view of the back surface of the porous boron doped carbon film comprising diRuthenium/diRuthenium molecules and siderophore plate of the filter material of the present invention.

[0016] FIG. **3** shows a prospective view of the surface of the synthetic film comprising zeolite crystalline bodies of the filter material of the present invention.

[0017] FIG. **4** shows a prospective view of the front surface of the synthetic film comprising zeolite crystalline bodies set in a frame.

[0018] FIG. **5** shows a prospective view of the front surface of the screen with a bifurcated airflow accelerator connected to the frame of the filter material of the present invention.

[0019] FIG. **6** shows a cross section view of the pneumatic valve/bifurcated airflow accelerator connection and fluidic amplifying tube of the present invention.

[0020] FIG. **7**A shows a cross section of the pneumatic valve section of the device in which the pneumatic valve is in the neutral position.

[0021] FIG. **7**B shows a cross section of the pneumatic valve section of the device in which the pneumatic valve is in the position that closes the first junction of the bifurcated airflow accelerator of the present invention.

[0022] FIG. **7**C shows a cross section of the pneumatic valve section of the device in which the pneumatic valve is in the position that closes the second junction of the bifurcated airflow accelerator of the present invention.

[0023] FIG. **8** shows a prospective view of the cartridge/cartridge holder inserted in the device.

[0024] FIG. **9** shows a cross section of the cartridge.

[0025] FIG. **10** shows a cross section of the flow booster attached to the flow booster tube of the present invention.

[0026] FIG. **11** shows an exploded prospective view of the flow booster of the present invention.

[0027] FIG. **12** shows a front prospective view of the patient-breathing device of the present invention.

[0028] FIG. **13** shows a side prospective view of the patient breathing device of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0029] The present invention is directed to a high oxygen generating apparatus comprising numerous repeating oxygen filtering units. Each repeating unit comprising two different screens having a frame and a filter material. The filter material of the first screen and the second screen are designed to complimentarily operate with each other so as to chemically produce bimolecular oxygen and hydrogen from water comprising two different screens. One screen being catalytic and the other being an ultra-filtration screen arranged in an alternating repeating arrangement. In particular, the alternating arrangement of the screens is specifically designed to prevent both the build up of radical intermediates during oxygen generation that may cause the decomposition of the oxygen generating filters as well as of the build up of excess water on the filter material which is known to reduce the functionality of such filters.

[0030] The apparatus of the present invention is designed so that it can either be used as a portable breathing device above or below water, as a device that is less portable (or even stationary) that is able to produce oxygen for several patients, an apparatus for producing oxygen for industrial applications and/or any other application that requires the production of oxygen. That is, that present invention provides an apparatus for producing oxygen and/or hydrogen gas from a source comprising a tubular and solid frame having an area configured to accommodate a cartridge. The cartridge used in the apparatus is configured to accommodate a plurality of repeating units containing filter material in the form of screens. The electro-generating catalyst material of the plurality of repeating units, alternating with zeolite containing screens, is designed to chemically split water into bimolecular oxygen and hydrogen for breathing. The repeating units of zeolite screens used for filtration and diRuthenium containing screens are further described immediately following the structure of the apparatus.

[0031] In one embodiment of the present invention, the apparatus is configured to have a mouthpiece that funnels exhaled air from a patient to a tubular frame where it is distributed in such a way so as to provide a flow of air over the filter material and catalyst thin film of the present invention. Water vapor from exhaled air and/or from air obtained from the surrounding atmosphere is chemically split into oxygen and hydrogen as it flows across/through the filter material of the present invention. The oxygen flow is then circulated back to the patient for respiration.

[0032] The apparatus of the present invention can further comprise, in addition to the mouthpiece, or in the alternative in place of the mouthpiece, a flow booster. The flow booster is designed to draw air in from the surrounding atmosphere as well as from a mechanically operating air source such as a miniature fan motor. The flow booster comprises a first and second nozzle positioned within each other and within an enclosure. The first and second nozzles are open at both ends and have a wide end tapering to a narrower end. The wide ends of the first and second nozzles are positioned in communication with an air-generating device, such as a fan. The enclosure of the flow booster has a plurality of holes positioned above the first and second nozzles which are able to draw additional air into the flow booster due to a Venturi effect created as air exits the first nozzle into the second nozzle.

[0033] In the embodiment that comprises both the mouthpiece and the flow booster, the two airflow devices are attached to the frame by a bi-furcated accelerator having a flap valve and at least two junctions. The first junction is configured to be in fluid communication proximal with the mouth region and the second junction in communication with the flow booster of the invention. The flap valve of the present invention is designed so as to have a first and second position. When the flap valve is in the first position a first leg of the bi-furcated accelerator is closed and a second leg is open. When the flap valve is in the second position the second leg of the bifurcated accelerator is closed and the first leg is open. The activation of the flap valve from the first to the second position is accomplished via the breathing pattern of the patient attached to the apparatus of the present invention. The flap valve can be a pneumatic valve actuated by air wherein the hollow tube of the bi-furcated accelerator is a fluidic amplifier configured to amplify air from the mouthpiece (or flow booster) so as to provide sufficient air flow to actuate the pneumatic flap valve.

[0034] In embodiments that do not have a mouthpiece but instead only have a flow booster, either the flap valve can be permanently closed in one position or in the alternative the accelerator is a single tube and no flap valve is necessary. The same configuration would also accommodate an embodiment where only a mouthpiece is present and no flow booster. These embodiments are also envisioned to be within the inventive construct of the present invention.

[0035] The apparatus of the present invention further comprises a plurality of blow-by accelerator nozzles that are in communication with the hollow portion of the frame of each screen and the overall device. The blow-by accelerator nozzles are instrumental in providing air (during the exhalation phase and from the flow booster) over the filter material of the present invention. In addition to the blow-by accelerator nozzles, the apparatus also contains a plurality of scavenger nozzles that are in communication with the frame and are positioned across from the plurality of blow-by accelerator nozzles. The combination of the plurality of accelerator nozzles (that are paralleled and flow air across the surface of the filter material) and the plurality of scavenger nozzles (that remove un-reacted air flow, by-products and excess charge buildup from the air flow over the filter) provides a flow of air for the continued operation of the filter material and captures un-reacted air flow, by-products, oxygen and hydrogen into the frame to be used and/or vented out of the apparatus.

[0036] To facilitate the flow of air across the filter material, the blow-by accelerator nozzles can be designed to have a wide end that is attached to the frame and a narrower end positioned at least partially over the filter material so that air from the blow-by accelerator nozzles flows over the filter material. The scavenger nozzles of the present invention have the reverse design. That is, the scavenger ports can have a narrow end attached to the frame and a wide end positioned at least partially over the filter material so that un-reacted air flow and by-products from the blow-by accelerator ports is captured by the scavenger ports and channeled into the frame to be used and/or vented out of the apparatus.

[0037] In an alternative embodiment of the present invention, the apparatus can be configured to supply air flow solely from the surrounding atmosphere and once oxygen and/or hydrogen is produced, the gas(es) can be stored in a storage vessel so that the gases can be used to support the oxygen needs of a plurality of patients. Here, several cartridges can be used in series so that the additional flow of air can be fully utilized and more bimolecular oxygen can be produced. Still further, the apparatus can be designed so that the filters generate bimolecular oxygen from atmospheric air and an alternative source instead of exhaled air from a patient as described above. The preferred embodiment, however, is the apparatus that gathers airflow from both a patient and the surrounding atmosphere via the flow booster. All of these configurations are envisioned to fall within the scope of the present invention and are designed to use the catalytic and filtering screens of the present invention.

[0038] Accordingly, as discussed above, the cartridge of the present invention is configured to accommodate a plurality of repeating units (filter materials) that are equipped with blow-by accelerator ports and scavenger ports in fluid communication with at least a portion of the frame and in close proximity to each filter material containing screen of the repeating unit.

The mouthpiece, flow booster, and the acceleration tube are placed in fluid communication with the catalyst and filter material of each of screens in the cartridge once the cartridge is inserted in the designated slot of the apparatus. This provides ample airflow to the apparatus of the present invention so that water can be chemically split into bimolecular oxygen and hydrogen for breathing or industrial use. The repeating units are further described below.

[0039] The first screen of the alternating filter material is a porous boron doped carbon film comprising diRuthenium/diRuthenium molecules and at least one type of electronegative ion directly attached to the carbon film. The second screen arranged behind the first screen is made out of a synthetic film comprising at least one zeolite crystalline body in direct contact with concentrically arranged nanocarbon tubules attached to the synthetic film. The synthetic film comprises a multiplicity of pores having a diameter of about 0.1 nm to about 3.0 nm. The zeolite crystalline bodies are attached to the nanocarbon tubules and overlap at least a portion of the pores. It is this structure that makes up a single repeatable unit and can be placed in series to generate high out of Oxygen from a given source.

[0040] The synthetic film comprises a multiplicity of pores having a diameter of about 0.1 to about 3.0 nm. The zeolite crystalline bodies are attached to the nanocarbon tubules and overlap at least a portion of the pores. It is this structure that makes up a single repeatable unit and can be placed in series to generate high oxygen output form water vapor from exhaled air or another source.

[0041] The unique diRuthenium/diRuthenium molecule used in the first screen contains several Ruthenium atoms. Chemically "Ruthenium" is generally found in ores with the other platinum group metals in the Ural Mountains and in North and South America. Small but commercially important quantities are also found in pentlandite extracted from Sudbury, Ontario and in pyroxenite deposits in South Africa. Commercially Ruthenium is isolated through a complex chemical process in which hydrogen is used to reduce ammonium ruthenium chloride yielding a powder. The powder is then consolidated by powder metallurgy techniques. Historically, Ruthenium was realized out of residues that were left after dissolving crude platinum. Ruthenium is a transition metal and as with most transition metals are excellent Lewis acids. That is they readily accept electrons from many molecules or ions that act as Lewis bases. When a Lewis base donates its electron pair to a Lewis acid, it is said to coordinate to the Lewis acid and form a coordinate covalent bond. When Lewis bases coordinate to metals acting as Lewis acids and form an integral structural unit, a coordination compound is formed. In this type of compound, or complex, the Lewis bases are called ligands and such ligands may be cationic, anionic or charge neutral.

[0042] Another portion of the Ruthenium complex of the present invention is a Polyoxometalates or "POM." As a class, POMs are very functional for use as catalysts and are able to activate molecular oxygen and/or hydrogen peroxide as reagents in oxidation reactions. However, one of the major problems with using Ruthenium containing molecules as catalyst is the degeneration of the Ruthenium catalyst and the danger of Ruthenium poisoning to those in contact with the ions which may become dislodged/decomposed from the catalyst. The design of the filter material of the present invention overcomes these problems in part by using a uniquely designed siderophore, and in part by electrically charging the siderophore and nanocarbon tubules in contact with the siderophore.

[0043] The first screen of the filter material of the present invention comprises a boron doped synthetic carbon thin film and a charged plate bonded to the opposite side of the synthetic carbon film than the Ruthenium complex. Both the boron doped synthetic carbon thin film and the charged plate function synergistically as siderophores. A siderophore is a compound that will attract and bond free charged ions. In other words, a complex that will capture freely charged ions before the ions continue through the filter materials and out of the filter and into the airflow of a person. The siderophores of the present invention are negatively charged so as to be specific for positive charged ions including free Ruthenium ions. Thus, capturing any positive Ruthenium ions that may become dislodged from the diRuthenium/diRuthenium complex of the present invention overcomes the shortcomings of using Ruthenium as a catalyst for generating oxygen and therefore provides a safeguard against Ruthenium poisoning.

[0044] One embodiment of the present provides a filter material for slitting oxygen and/or hydrogen gas from a water source comprising a porous boron doped carbon film having diRuthenium/diRuthenium molecules and at least one type of electronegative ion attached either directly to the carbon film or, optionally, via an intermediate compound and/or structure. Whether the diRuthenium/diRuthenium molecules of the present invention are in direct contact with porous boron doped carbon film or are attached via an intermediate compound and/or structure, they are ionically bonded.

[0045] In one embodiment of the present invention, one diRuthenium molecule of each of the diRuthenium/diRuthenium molecules of the present invention has the following formula (I) $[Ru_2(CO)_4(u\text{-}n^{2-}O_2CR)_2L_2]_x$ wherein u is a bridging ligand selected from the group consisting of $[Ru_2(EDTA)_2]^{2-}$, $(CO)_4$, F^-,CO_3^{-2}, NO^+ (Cationic), Hydrogen-bonded aromatic/carboxylic Acid-(either for multiple attachments as polymerization or singular, at the double bonded oxygen or sites within), ethylenediamine, halides as anionic ligands, carboxylic acid, unsaturated hydrocarbons, Nitric Acid coordinating to a metal center either linear or bent, butadiene, carboxylate ligands, anionic (RO— and RCO_2^{-2} (wherein R is H or alkyl group) or neutral ligands (R_2, R_2S, CO, CN^-), CH_3CN (Acetonitrile), NH_3 (Ammonia amine) F^-,Cl^-, tris(pyrazolyl)borates as Scorpionate Ligand" a boron bound to three pyrazoles; the "pincers" of the compound refer to the nitrogen hetero atoms from two of the pyrazole groups ($C_3H_4N_2$) which can bind a metal) and mixtures thereof, preferably $[Ru_2(EDTA)_2]^{2-}$;

wherein n is at least 2 and depends on the denticity of the molecule—(that is, the number of donor groups from a given ligand attached to the same central atom);

wherein L is a ligand selected from the group consisting of $[Ru_2(Ph_2PCH_2CH_2PPh_2)(EDTA)]^{2+}$, C_6H_6, $R_2C{=}CR_2$ (wherein R is H or an alkyl), 1,1-Bisdiphenylphosphino methane, diethylenetriamine [diene] bonds preferably tridentate, triazacyclononane [diene] bonds preferably tridentate, triphenylphosphine and mixtures thereof;

wherein CR is carboxylic acid, carboxylate ligands, anionic (RO^- and RCO_2^- (wherein R is an alkyl group)) or neutral ligands (R_2,R_2S, CO^-, CN^- (wherein R is an alkyl group)) and mixtures thereof; and x is about 1 to about 30, preferably 1 to about 20 and more preferably 1 to about 10.

[0046] The other molecule of the diRuthenium/diRuthenium molecules of the present invention is a diRuthenium-substituted polyoxometalate having the following formula (II) $[WZnRu^{III}_2(OH)(H_2O)(ZnW_9O_{34})_2]$ which is converted to $Ru_2Zn_2(H_2O)_2(ZnW_9O_{34})_2^{-14}$ in the effective catalyst. The distance between each Ruthenium in the diRuthenium molecule is about 2.0 angstroms to about 3.0 angstroms, preferably about 2.25 angstroms to about 3.0, and more preferably about 2.50 angstroms to about 2.80 angstroms.

[0047] In one particular embodiment of the present invention, the di-ruthenium-substituted polyoxometalates described in U.S. Pat. No. 7,208,244 to Shannon et al., the entirety of which is herein incorporated by reference, can be used to in connection with the boron doped carbon thin film as described above so as to provide the benefits of the inventive filter material.

[0048] In yet another embodiment of the present invention, the filter material further comprises a Ruthenium ion capturing siderophore plate connected to the opposite surface of the carbon film in which the diRuthenium/diRuthenium molecule is attached. The siderophore plate is ionically charged so as capture free Ruthenium ions that become dislodged from the porous boron doped carbon film. The siderophore plate can be selected from the group consisting of negative or positive charged ions, and resin clay in which the clay is molded into a hollow tubular plate having a plurality of pores. In particular, the siderophore plates can be polysulfinate impregnated resin plates, ethylenediaminetetraacetic acid (EDTA) containing plates and mixtures thereof.

[0049] In one embodiment of the present invention the siderophore plate is attached to one end of the nanotubules of the carbon doped film and at least a portion of the siderophore plate is directly attached and/or embedded into the thin film. This design allows the siderophore plate to be capable of capturing and ionically bonding free Ruthenium ions. As discussed above, this is essential when the filter material is used to produce oxygen for breathing. In an embodiment wherein oxygen produced by the filter material is not used for breathing but is used instead is used for an industrial process, the siderophore plate is less important.

[0050] In yet another embodiment of the present invention, the porous boron doped carbon film can further comprises a nanocarbon tubular mesh network. The nanotubules of the nanocarbon tubular mesh network have a diameter of about 20 nanometers to about 450 nanometers, preferable 20 nanometers to about 250 nanometers and more preferably about 20 nanometers to about 100 nanometers. The nanocarbon tubular mesh network is designed so that each tubule can carry current in extremely low resistance flow that is used to destabilize the oxygen-hydrogen bonds in water so as to make the hydrogen-oxygen bonds easier to split in order to produce bimolecular oxygen and/or hydrogen. According, the energy and the time necessary to split these bonds is less, thus making it quicker and easier to produce bimolecular oxygen. The nanotubular network extends above the supporting POM matrix by about 0.2 to about 5.0 microns.

[0051] Attaching the diRuthenium to the carbon thin film begins with the attachment of the carbon to a substrate. In one embodiment of the present invention a silicon substrate, or its like, is used to allow the carbon atoms from Chemical Vapor Deposition (CDV) to nucleate on the substrate surface initiating the tetrahedral coordinated Sp^3 orbital network. The CDV use hydrogen and methane as precursor gases and use the “heated methodology”. The heated methodology, for example, can use a filament to provide the diffusion of the reactive species mostly “methyl radical” to interact with the substrate surface and allow the carbon atoms to be absorbed by the surface and growth coalescence to occur. Once complete, the thin-filmed surface is primarily tertiary carbon atoms with single C—H bonds.

[0052] The doping of the carbon thin film may be completed using boron, fluorine and/or nitrogen. With increased concentrations of the doping level, the insulator behavior of the diamond (carbon) alters to one of a semiconductor and further to a full metallic behavior. In order to achieve this electrochemistry effect, the level of boron doping has to be sufficient to cause a low ohmic drop in the diamond (carbon) level, but not so low as to alter or disturb the crystalline structure thereby inducing a graphite phase during the doping synthesis. One way this can be achieved is to do the doping with Fluorine as a compounded vapor, where upon contact with the carbon thin film, the Fluorine interacts with both the hydrogen and boron forming a bond as the ion. Another possible way to achieve this is doping the carbon with a mixture of both boron and fluorine. As fluorine is a case of negative doping i.e., the negative F ion has an extra electron and a slightly lower energy level. (i.e. about 0.028-0.32 eV as opposed to Boron at about 0.35 eV). Typically, the carbon-fluoride bond is covalent and very stable, as can be seen in several common fluorocarbon polymers, such as, poly(tetrafluoroethane) and Teflon. In the alternative, the invention may utilize the deposition of graphite onto the substrate to produce carbon deposition by micromechanical cleavage of high quality graphite.

[0053] Still yet another alternative to produce the carbon doped by boron and fluorine ion to substrate is to vapourize the Boron Oxide and low volume-molar Hydroflourine (less than about 0.22 litters to about 0.34 liters per about 1.9 liters to about 2.5 liters methane). As discussed above, fluorine containing compounds such as, perfluoroalkyl-alkoxy silanes and/or trifluoropropyl-trimethoxysilane (TFPTMOS), can be used to interact with the carbon boron doped thin film providing that the fluorine containing compound has at least one carbon-metal bond per molecule.

[0054] The thin film produced functions as a Semiconductor. In addition to its semiconductor effect, the DiRuthenium/diRuthenium screen composed of the boron doped synthetic diamond (carbon) thin film is used as anchor to keep the alignment of the Ruthenium complexes in the sawhorse orientation and to keep the POM from excessively separating and twisting when flows greater than 20 liters/min and/or water flows of greater than 4 liters/25 seconds are passed across the filter material of the present invention. Therefore, not only does the boron doped carbon thin film provide semiconductor properties, but it also functions to prevent the diRuthenium molecules from becoming distorted under high flows. In addition, the boron doped carbon thin film together with the fluorine causes an inductive effect (l−) that amplifies the electronegative moiety bonded to the sawhorse orientated Ruthenium complex as well as both inner sphere ligands while equally extending out to the diRuthenium-POM as outer sphere bonding.

[0055] The “Sawhorse molecule” can complex/bond to the to POM molecule either covalently, ionically and/or by coordination complexing. In particular, the bonding technique between the sawhorse molecule and the POM molecule is ionically-like bonded, since the complex uses the inductive effect from the F^- attached to the Sawhorse in order to complex with POM. The inductive effect in chemistry is an experimentally observable effect of the transmission of charge through a chain of atoms in a molecule by electrostatic induction (IUPAC definition). The net polar effect exerted by a substituent is a combination of this inductive effect and the mesomeric effect. The electron cloud in a s-bond between two unlike atoms is not uniform and is slightly displaced towards the more electronegative of the two atoms. This causes a permanent state of bond polarization, where the more electronegative atom (in our case the F^- has a slightly negative charge(d−) and the other atom has a slight positive charge (d+). If the electronegative atom (F−) is then joined to a chain of atoms, usually carbon (O_2 RC derivatives of carboxylic acid at ligand points in the sawhorse), the positive charge is relayed to the other atoms in the chain (across the Sawhorse to the POM giving an electron-withdrawing inductive effect, also known as the –l effect.)

[0056] If a purely "ionic bonded Sawhorse to POM species" is used in the present invention, then additionally known bridging ligands between the Ruthenium Sawhorse core is offered as the anion $[Ru_2(EDTA)_2]^{2-}[Ru_2(EDTA)_2]^{2-}$ and the bridging ligand is used as the cation (such as $[Ru_2(Ph_2PCH_2CH_2PPh_2)(EDTA)]^{2+}$) which can then be linked by forming an amide with triethylene diamine, $H_2NCH_2CH_2CH_2NH_2$. This is used both as the specific ligand to bind the two molecule core and Ruthenium Substituted Polyoxometalate (RPOM), $WZnRu_2^{III}(OH)(H_2O(ZnW_9O_{34})_2]^{11}$. This done so as to a) not decimate the sawhorse molecule, and B) to contribute to the electro-generating capabilities for generating high purity (>97%) Oxygen as end product. This can be achieved by the close proximity of additional ruthenium atoms, even under great repulsive strain, which is not the case when a metal carbide intermediary is used.

[0057] The carbon in the diamond or graphite structure is sp^3 hybridized while the Boron (non carbon, i.e., non-diamond) is a sp^2 species. The specific hybridization states of the carbon and boron discussed above are important in providing electrical conductance to the thin film so that the thin film functions as both an anchoring substrate and an oxygen-generating electrode. In order to be effective for the stated purpose above, the thin film must be boron doped in a range between about 2100 ppm to about 6,800-ppm/0.1 cm of thin film (screen) size.

[0058] In yet another embodiment of the present invention, the filter material of the present invention further comprises a synthetic film having a plurality of nanocarbon tubules attached and/or embedded thereon to form a nanocarbon tubule mesh network. The synthetic film of the present invention is selected from the group consisting of SiO_4, AlO_4, and mixtures thereof. The crystal structure of zeolites typically is based upon repeating units consisting of a silicon atom (+4 valence) surrounded by four oxygen atoms (−2 valence) in a tetrahedral configuration. Two Si atoms, giving the tetrahedral net valence of zero, share an oxygen molecule. When aluminum (with a valence of +3) is substituted in the tetrahedral orientation, a net charge −1 occurs and thus gives rise to the cation exchange properties of zeolites (further discussed below). The synthetic film is positioned proximal to the surface of the porous boron doped carbon film in which the siderophore is attached. The synthetic film of the present invention further comprising at least one zeolite crystalline body that is in direct contact with the nanocarbon tubule mesh network attached and/or embedded thereon. The synthetic film has a multiplicity of pores with a diameter of about 0.1 to about 3.4 nm, preferably about 0.1 nm to about 3.0 nm and more preferably about to about 2.0 nm to about 2.9 nm.

[0059] Zeolites typically are hydrated aluminosilicate minerals having micro-porous structures. Accordingly, the synthetic zeolite synthetic film of the present invention operates as a molecular sieve where the maximum size of the molecular or ionic species that can enter the pores of a zeolite is controlled by the diameters of the tunnels in the seive that are conventionally defined by the ring size of the aperture. For example, a zeolite complex having an 8-ring structure is a closed loop built from 8 tetrahedrally coordinated silicon (or aluminum) atoms and 8 oxygen atoms and itself comprises a multiplicity of pores. In other words, the size of the apertures in the zeolite synthetic film that controls entry of the particular ions into the internal pore volume of the zeolite synthetic film is determined by the number of T atoms (T=Si or Al) and oxygen in the ring. The apertures are classified as ultra large (>12 membered ring), large (**12**), medium (**10**) or small (**8**). Aperture sizes range form about 0.4 nm for an 8 ring structure such as zeolite A, about 0.54 nm for a 10 ring structure such as ZSM-5 and about 7.4 nm for a 12 ring structure such as zeolite X and ZSM-12, all of which can be used in the present invention.

[0060] The synthetic film itself comprises a multiplicity of pores having a diameter of about 0.1 to about 3.0 nm providing an oxygen sieving effect (0_2=2.96 A° and N_2=3.16 A°). The zeolite crystalline bodies attached to the nanocarbon tubules overlap at least part of the pores. The porous boron doped carbon film comprising diRuthenium/diRuthenium molecules together with the thin synthetic film having carbon nanotubules attached and zeolite crystalline bodies in direct contact with the nanocarbon tubules form a repeating unit that can be used to make up the filter material of the present invention.

[0061] Zeolites used in the present invention have a crystal structure constructed from a TO_4 tetrahedral configuration, where T is either Si or Al. In addition to a large number of naturally occurring zeolites, there is a wide range of synthetic zeolites as well. As stated above, the crystal structure of zeolites is based upon repeating units consisting of a silicon atom (+4 valence) surrounded by four oxygen atoms (−2 valence) in a tetrahedral configuration. Each oxygen atom is shared by two Si atoms, giving the zeolite its tetrahedral structure and a net charge of zero. When aluminum (with a valence of +3) is substituted in the tetrahedral configuration the zeolite will have a net charge of −1. This negative charge gives rise to the cation exchange properties of zeolites. Zeolites also have very uniform defined pore sizes as well as high porosity, which occur as a consequence of their unique crystal structures. For this reason, zeolites are useful as molecular sieves.

[0062] In one embodiment of the present invention, the zeolite crystalline bodies are directly attached to the nanocarbon tubules of the nanocarbon tubule mesh network so that the zeolite crystalline bodies overlap at least part of the pores in the synthetic film. This configuration allows oxygen and/or hydrogen generated from the reaction of water molecules with the zeolite/nanotubules (and diRuthenium complex described above) to flow through the pores of the synthetic film to be collected and used for a given purpose. It is the combination of the diRuthenium/diRuthenium containing porous boron doped carbon film and the synthetic film containing zeolite crystalline bodies attached to the nanocarbon tubular mesh network overlapping at least part of the pores in the synthetic film that forms a repeating unit of the filter material of the present invention.

[0063] However, un-split water frequently blocks the pores of certain zeolites and therefore often these zeolites often become fouled and loss their separation qualities. The structure of the filter material of the present invention allows the zeolites attached to the tubular mesh network to remain "unclogged" and functional for a longer period of time because the nanotubules of the present filter material destabilizes the hydrogen/oxygen bond in water thereby making it easier for the diRuthenium molecules of the filter material to split water into oxygen and hydrogen. The more water that is split by the diRuthenium molecules, the more oxygen/hydrogen is generated and the less water available to clog the pores of the zeolite attached to the nanotubules of the synthetic film of the present invention. Once the oxygen and/or hydrogen are generated it can be captured and used for breathing, storage or industrial uses.

[0064] The pore size of the zeolites used is also critical. If the pores are too large water can pass through the zeolite filter and not be filtered to oxygen and hydrogen, too small the oxygen and/or hydrogen produced can be retained and not passed out of the filter so that they can be utilized. Therefore, it is important that it is possible to fine-tune the pore opening of zeolites so as to allow the adsorption of specific molecules while excluding others based on size. One method to change the pore size of the zeolite is to change the exchangeable cation from one cation to another. For example, when Na+ ions are replaced by Ca++ ions in zeolite A, the effective aperture size increases. This can also be accomplished by changing the Al/Si ratio in the zeolite. An increase in the ratio of Si to Al will slightly decrease the unit cell size, decrease the number of exchangeable cations, thus freeing the channels and make the zeolite more hydrophobic in character.

[0065] Zeolite used in the present invention are mainly composed of alumin-silicates wherein the alumina substrate contains alumina pores that function as molecular sieves that allow some atoms to pass through but excludes others so produce a chosen end product. For purpose of this application the term "molecular sieve" refers to a particular property of selectively sorting molecules based primarily on a size exclusion process. The zeolites that can be used in the present invention include any one of a family of hydrous aluminum silicate minerals, typically alkali metals and alkaline earth metals whose molecules enclose cations of sodium, potassium, calcium, strontium, or barium, or a corresponding synthetic compound.

[0066] Accordingly, the filter material of the present invention is constructed from the repeating unit comprising the boron carbon doped film containing diRuthenium molecules on one side of the film and an siderophore to capture free Ruthenium ions on the other, followed by a synthetic film containing a carbon nanotubular mesh network attached to synthetic film and the zeolite crystalline bodies. Several of these repeating units can be amassed in series so as to provide a filter material for high output oxygen and/or hydrogen generation. This unique filter material combines two different materials, which results in a new material having characteristics that are different than those of the basic materials. As such, the filter material of the present invention not only electro-generates a high quantity of bimolecular oxygen but using the direct pass through filtration via the molecular sieve "Zeolite media," to capture bimolecular oxygen for use for breathing devices, storage of oxygen for future use or industrial usage.

[0067] The nanocarbon tubular mesh network embedded on the surface of the synthetic film extends about 0.1 to about 7 millimeters above the surface of the zeolite coating synthetic film, preferably about 0.2 to about 6 millimeters and more preferably about 0.2 to about 5 millimeters. As with the nanotubules associated with the diRuthenium containing carbon-doped film, the nanocarbon tubules can have a diameter of about 20 nanometers to about 450 nanometers. The nanocarbon tubular mesh network can be embedded on the surface of the synthetic film using electron-beam lithography, atomic force microscopy, chemically charged molecular ink, crystallization self-assembly, seeded self-assembly, and/or mixtures as well as any other procedure that does not affect the pores of the synthetic film to which it is embedded.

[0068] One method that can be used to assure that the filter material of the present invention has the proper arrangement is direct visualization during the embedding process by "IBM Almaden's Materials Characterization and Analysis Lab," which uses a FEI 830 Dual Beam system that integrates the FIB (Focused Ion Beam) with a ultra-high-resolution SEM. The methods allow the analyst to capture an image of a specific site while performing a milling or deposition procedure. In making the carbon thin film, the thin film is first milled by accelerated gallium ions so as to dig the initial hole for the nanocarbon tubules to be embedded with the born doped thin film. Once completed, a carbon metal oxide is deposited within the milled region to form a pattern and underside of the carbon tubules while an inert gas, such as Argon, is pumped onto the surface of the thin film. Additional carbon doped atoms are deposited onto the argon gas surface above the nanocarbon tubule concavity previously formed in the thin film by the gallium ions. The deposition may be completed either by ALD (atomic Layer Deposition) or CVD so that the carbon tubules are laid down in a concentric pattern extending from the innermost point of the thin film outward. Once carbon nanotubule is completed, the end portion of the carbon nanotubule is left open so that current can be applied within the carbon nanotubules. The diRuthenium molecules are then either aerosolized onto the prepared surface or applied using CVD so as to bond with the boron fluorine at the newly prepared thin film surface.

[0069] In the alternative, the method used to form the Carbon Boron doped Fluoride film could be by radio frequency magnetron sputtering using a composite target consisting of h-BN and graphite in an Ar—F_2 gas mixture, The Ar—F_2 gas mixture formed by photolysis of hydrogen fluoride in a solid argon matrix leads to the formation of argon fluorohydride (HArF). Subsequent to the formation, the carbon doped fluoride thin film may be characterized by X-ray diffraction, Fourier transform infrared spectroscopy and/or X-ray photoelectron spectroscopy. Descriptions of these procedures can be found in Preparation of boron carbon nitride thin films by radio frequency magnetron sputtering, *Applied Surface Science*, Volume 252, Issue 12, 15 Apr. 2006, Pages 4185-4189. Lihua Liu, Yuxin Wang, Kecheng Feng, Yingai Li, Weiqing Li, Chunhong Zhao, Yongnian Zhao; and A stable argon compound, Leonid Khriachtchev, Mika Pettersson, Nino Runeberg, Jan Lundell & Markku Räsänen. Department of Chemistry, PO Box **55** (A. I. Virtasen aukio 1), FIN-00014 University of Helsinki, Finland. *Nature* 406, 874-876 (24 Aug. 2000).

[0070] The nanocarbon tubular mesh network of both the boron doped film and the synthetic film can be arranged in concentric spaced circles starting form the center region of the either the porous boron doped carbon film or the zeolite synthetic film outwards.

[0071] Overall the filter material of the present invention is designed so that the zeolite synthetic film screen is placed behind the diRuthenium boron doped thin film screen so that the diRuthenium screen is proximal to the air flow, i.e., the airflow contacts the diRuthenium screen first. In this way moisture contained in the airflow is impacted and electrochemically aided so as to enhance the splitting of water into oxygen and hydrogen. The zeolite and diRuthenium screens function in tandem. In one preferred embodiment of the present invention, a set of six screens can be contained within a cartridge having a frame that can be used in a patient breathing device. The diRuthenium center and outer border sandwiching the zeolite center bonded to and surrounded by diRuthenium walls can be analyzed postproduction by FTIR and or X-ray crystallography for its accuracy and bonded interface.

[0072] The cartridge is designed so that it can be removed and replaced when needed. The cartridge can be made to be recyclable or can be a single use device. Many different configurations for the cartridge are possible and do not limit or change the functionality of the filter material of the invention. That is, providing filter material that alternates between a new type of diRuthenium/diRuthenium boron doped thin film screen and a new type of zeolite synthetic film screen that functions in tandem to produce bimolecular oxygen to an individual patient for breathing, to an oxygen storage device or to an industrial consumer. As stated above the present inventions unique design simultaneously prevents build up of radical intermediates during oxygen generation and prevents decomposition of the oxygen catalysts and anion electrodes used in the filter material of the present invention.

[0073] Specific embodiments of the present invention are described in conjunction with the attached figures in order to better describe the invention and should not be regarded as limiting the present invention in any way.

[0074] FIG. **1** shows a prospective view of the front surface of the porous boron doped carbon film comprising diRuthenium/diRuthenium molecules of the filter material of the present invention (**10**). As stated above and shown in FIG. **1**, the mesh-like material in which the screen is made of is a carbon boron doped screen (**15**) having a top (**55**), a bottom (**60**), a right side (**45**) and a left side (**50**). Alternative shapes such as circular, oval, elliptical, parallelograms in particular, square, rectangular and triangular are also within the scope of the invention.

[0075] FIG. **1** shows a rectangular screen for description purposes only but other shapes are envisioned to fall within the scope of the present invention. Deposed or embedded on/in the carbon boron doped screen (**15**) are nanocarbon tubules (**20**) that originate from a central point in the screen and radiate outwards to form a loosely packed coil structure in a concentric arrangement. Although the nanocarbon tubules are concentrically arranged, in the alternative the carbon nanotubules can be arranged in different patterns depending on the design and shape of the carbon boron doped screen (**15**). The different arrangements of the nanotubules, as with the different shapes of the screen, are also envisioned to fall within the scope of the invention.

[0076] Dispersed throughout the carbon boron doped screen (**15**) are numerous boron atoms (**25**). These boron atoms (**25**) can be evenly dispersed throughout the screen or may be concentrated within the area of the nanocarbon tubules. Approximately in the center region of the nanocarbon screen (**15**) is at least one diRuthenium-substituted polyoxometalate (POM) complex (**40**). As described above, in one embodiment of the present invention the diRuthenium-substituted polyoxometalate (POM) complex (**40**) comprises a diRuthenium sawhorse molecule (**35**) attached to a POM (**30**). The diRuthenium sawhorse molecule (**35**) is located closet to the screen while the POM (**30**) extends out of the face of the screen. This arrangement allows for quick and efficient degradation of water into bimolecular oxygen and hydrogen. This arrangement makes up the structural arrangement of the first screen of the repeating unit of the filter material of the present invention.

[0077] FIG. **2** shows a prospective view of the back surface of the porous boron doped carbon film (**100**) comprising diRuthenium/diRuthenium molecules and a siderophore (**115**). The carbon boron doped screen of the invention has a top (**105**), bottom (**110**), a left side (**120**) and a right side (**125**). The siderophore (**115**) is shown in FIG. **2** as being located at the bottom (**110**) of the screen, however, it is within the scope of the invention for the siderophore (**115**) to be located in other portions of the screen depending on the shape of the screen and the arrangement of the nanotubules. The carbon boron doped screen (**15**) contains boron atoms (**25**) as well as carbon nanotubules (**20**) and at least one diRuthenium-substituted polyoxometalate (POM) complex (**40**) as shown in FIG. **1** and discussed above.

[0078] The siderophore (**115**) can be in the form of a hollow tubular structure having a plurality of pores wherein at least one end of the siderophore (**115**) is in direct communication with at least one end of the nanocarbon tubules. In the alternative, the siderophore (**115**) can be in the form of an ionically charged plate. Either configuration is designed to capture charged ions such as, ruthenium ions that may become dislodged from the filter material so as to protect a patient breathing the oxygen produced by the filter material from inhaling the free ruthenium ions. Either the plate or the hollow tube siderophore (**115**) can be constructed from impregnated polysulfinate resin, ethylenediaminetetraacetic acid (EDTA) and mixtures thereof.

[0079] FIG. **3** shows a prospective view of the surface of the synthetic film comprising zeolite crystalline bodies of the present invention (**200**). This is the next screen in the repeating unit of the filter and is positioned facing the back surface of the boron doped carbon film having the siderophore shown in FIG. **2**. The synthetic film (**200**) has a top (**205**), a bottom (**210**), a right (**220**) and a left (**225**) side and is shown in a rectangular configuration. As with the first screen, the synthetic screen is shown in a rectangular shape but alternative shapes such as circular, oval, elliptical, parallelograms in particular, square, rectangular and triangular are envisioned to fall within the scope of the invention. That is, FIG. **3** shows a rectangular screen for description purposes only but other shapes fall within the scope of the present invention.

[0080] As with the boron doped carbon film of FIGS. **1** and **2**, the synthetic film of FIG. **3** has carbon nanotubules (**215**) embedded or deposed thereon. The synthetic screen also has zeolite crystalline bodies (**240**) in direct contact with the nanotubules (**215**), in direct contact with the synthetic film or in direct contact with both.

[0081] FIG. **4** shows a prospective view of the front surface of the synthetic film comprising zeolite molecules set in a frame (**130**). The filter/frame (**130**) of the filter material of the present invention comprises a frame (**135**) that is both structural and functions as a hollow tubular passage of gases to different regions of the filter screen. The frame is equipped with several blow-by nozzles (**145**) having a wide end (**155**) and a narrow end (**140**). The wide end (**155**) of the blow-by nozzles is connected to the frame (**135**) wherein the narrow end (**140**) extends over the zeolite crystalline screen (**170**). As air, either exhaled from the patient, taken from the atmosphere or produced from a fan motor (shown in FIG. **6**), passes into the frame (**135**) at least a portion of the air passes through the wide end of the blow-by nozzle (**155**) so as to exit the narrow end (**140**) positioned over the zeolite crystalline screen (**170**). It is from this air that Oxygen is adsorbed from constituents gases contained in air and is added to the Oxygen, and Hydrogen split from water from the catalyst screen.

[0082] The frame (**140**) is also equipped with scavengers (**175**) having a narrow end (**180**) that is attached to the frame (**140**) and a wide end (**185**) that extends over the zeolite crystalline screen (**170**). As described above, this specific configuration of the scavengers (**175**) allows for oxygen, excess water, excess gases, built up surface electrostatic charges, as well as waste gases that do not pass through the screen to be drawn into the wide end (**185**) of the scavengers (**175**) and into the frame (**135**) to be either collected and/or exhausted from the filter material. The specific design of the scavengers, having the wide end (**185**) positioned over the screen across from the blow by nozzles (**145**) and the narrow end (**180**) attached to the frame (**140**), where at this site in the frame a designed constriction accelerates the airflow which facilitates a suction into the scavenger nozzles that is able to draw in gases as described above.

[0083] The blow-by nozzles (**145**) are also specifically designed so as to propel the incoming air out of the nozzles (**145**) across the screen (**170**). That is, the wide end (**155**) of the blow-by nozzles (**145**) is attached to the frame (**140**) so that the path of the air entering the blow-by nozzles (**145**) is constricted to the narrow end (**140**), which exits out over the screen (**170**). The constricted path causes the airflow exiting over the screen to exit at a higher acceleration than when it enters. The frame (**130**) is also equipped with a first connection (**150**) and a second connection (**190**) that is designed to connect to with the bifurcated accelerator described above and shown in FIG. **6**. As with the filter shown in FIG. **3**, the synthetic film (**170**) has the same components shown therein, namely nanotubules (**165**) arranged in a concentric arrangement with zeolite atoms (**160**) associated therewith.

[0084] The boron doped carbon screen having the diRuthenium complex (**40**) shown in FIGS. **1** and **2** is also arranged in a frame as shown in FIG. **4** above. That is, the boron doped carbon screen shown in FIGS. **1** and **2** is set in a frame having scavengers and blow-by nozzles as described above and shown in FIG. **4** and is part of the repeating unit of the filtering material of the present invention.

[0085] FIG. **5** shows a prospective view of the front surface of the synthetic film containing zeolite crystalline bodies (**300**) with a bifurcated airflow accelerator (**305**) connected to the frame of the filter material of the present invention. The bi-furcated accelerator (**305**) has a main feed tube (**355**) that bifurcates to a first junction (**310**) and a second junction (**315**). The first and second junctions (**310 and 315**) are connected to the main feed tube (**355**) at a branch point (**360**) which has a pneumatic valve (shown in FIGS. **7A-7C**) positioned within. As described above and further described below the pneumatic valve is designed to divert air/fluid flow to either the first junction (**310**) or the second junction (**315**) of the bifurcated accelerator (**305**). In the embodiment shown in FIG. **5** the first junction (**310**) is further bifurcated into a first leg (**320**) and a second leg (**325**).

[0086] The first leg (**320**) of the first junction (**310**) is connected to frame attachment point (**335**) that is configured so that air/fluid flow exiting the first leg (**320**) of the first junction (**310**) flows to the scavenger nozzles shown in FIG. **4**. The second leg (**325**) of the first junction (**310**) is attached to frame connection point (**330**), which is configured so that air/fluid flow exiting the second leg (**325**) flows to the blow by nozzles (**355**). The blow-by nozzles are designed so as to further accelerate the flow of air as it exits across the surface of the synthetic film.

[0087] The second junction (**315**) of the bifurcated accelerator is positioned so that air/fluid that exits the second junction (**315**) exits directly into and over the synthetic film. The end of the second junction (**315**) can be equipped with an enlarged funnel screen (**340**) that aids in the distribution of air/fluid over the surface of the synthetic screen (**350**) so as to allow the adsorption of air, and or water into bimolecular oxygen and hydrogen of the zeolite screen. The same arrangement is also used for the boron doped carbon screen shown in FIGS. **1** and **2** and described above. In fact, each of the screens of the alternating units is configured as shown in FIG. **5**. That is, the nanocarbon boron doped screen and the synthetic zeolite screen each contain a bifurcated accelerator that is further branched so as to supply air/fluid to the scavengers and blow-by nozzles as well as to distribute flow across the surface of each screen.

[0088] FIG. **6** shows a cross section view of the pneumatic valve/bifurcated airflow accelerator connection of the present invention. The accelerator connection is connected to a mouth area tube (**405**) that is connected to a mouth area (**430**) as well as a flow booster tube (**410**), which connected to a flow booster (**415**). The flow booster (**415**) is further connected to a fan motor (**420**) that is designed to generate air flow through the flow booster (**415**) drawing in additional air from the surroundings as described above and further described below. The flow booster is shown in more detailed in FIGS. **10** and **11**.

[0089] The airflow from both the mouth area (**430**) and the flow booster (**420**) travel toward the pneumatic valve (**425**) system of the present invention. The pneumatic valve (**425**) is attached to a pivot point (**450**) that allows the valve to move towards either the first junction (**435**) or the second junction (**440**) of the bi-furcated accelerator tube. As discussed above, when a patient exhales out of the mouth area (**430**) airflow travels down the fluidic amplifier tube (**405**) and strikes the pneumatic valve (**425**) so as to cause the valve to pivot about the pivot point (**450**) in order to close off the second junction (**440**) of the bifurcated accelerator tube. With the pneumatic valve in this position, the air flows into the first junction (**435**) and is distributed to the blow-by nozzles and scavenger nozzles as discussed above. When the patient inhales, the pneumatic valve (**425**) pivots about pivot point (**450**) so as to close off the first junction (**435**) and airflow from the flow booster (**415**) travels down the flow booster tube (**410**) and into the second junction (**440**) so as to be distributed over the diRuthenium and zeolite screens also as discussed above. The different positions of the pneumatic valve (**425**) are further shown in FIGS. **7**A, **7**B and **7**C.

[0090] In FIG. **7**A, the pneumatic valve (**425**) is shown in the neutral position so that airflow travels into both the first and second junctions (**435** and **440**). In FIG. **7**B, the pneumatic valve (**425**) is shown closing the first junction (**435**) and air from the flow booster tube (**410**) travels into the second junction (**440**) where it is distributed over the diRuthenium and zeolite screens. In FIG. **7**C, the pneumatic valve (**425**) is shown closing the second junction (**435**) and airflow from the mouthpiece tube (**405**) travels into the first junction (**435**).

[0091] FIG. **8** shows a prospective view of the cartridge/cartridge holder including connections to the accelerator tube. As shown in FIG. **8**, a plurality of alternating screens of the filter materials of the present invention (**605**) can be positioned within a cartridge (**610**). The alternating stacked arrangement comprises a first boron doped carbon film containing diRuthenium/diRuthenium molecules and at least one siderophore as described above and the second screen is the zeolite containing synthetic film of the present invention. This arrangement is then repeated to make up the filtering material of the present invention that can be housed in filter cartridge (**610**) which can be inserted into filter cartridge holder.

[0092] The filter cartridge is configured so that the first leg of the first junction (**620**) can attach to the frame and distribute airflow to the blow by nozzles as discussed above. The filter cartridge is also configured so that the second leg of the first junction (**630**) can attach to the frame and distribute airflow to the scavenger nozzles as discussed above. Also shown in FIG. **8** is the connection of the flow booster tube (**640**) and the mouthpiece tube (**635**). The cartridge holder (**615**) can be designed so as to be disposable or in the alternative can be configured so as to allow for a new cartridge (**610**) to be inserted and replaced into the device. Both configurations are envisioned as part of the present invention.

[0093] FIG. **9** is a cross section of the cartridge holder (**615**) and cartridge (**610**) as shown in FIG. **8**. This cross section (**700**) shows the frame connected to each screen by first and second legs of the first junction (**725**). The filter material shows the repeating nanocarbon boron doped screens (**705**) and (**715**) separated by zeolite containing screens (**710**) and (**720**) to form the filter material in the cartridge. As stated above, although the cartridge is shown with two repeating units, either multiple cartridges or cartridges with additional screens can be used in the practice of the present invention.

[0094] FIG. **10** shows a cross section of the flow booster (**800**) that is attached to the flow booster tube of the present invention. The flow booster (**800**) is specifically designed so as to increase the flow of air into the flow booster tube of the present invention. As shown in the cross section view of the flow booster (**800**), a first funnel (**840**) is fitted within a second funnel (**835**) so that the throat or outflow (**810**) of the first funnel (**840**) is positioned within the flow passage (**815**) of the second funnel (**835**). The airflow from the throat (**810**) of the first funnel (**840**) exits the second funnel (**835**) at the outflow (**820**), which is in fluid communication with the flow booster tube shown in FIG. **6**. Directly above the second funnel (**835**) is a plurality of venturi conduits (**830**) configured to feed into the second funnel (**835**) and allow additional air to be drawn into the second funnel passageway (**815**) as airflow from the first funnel (**840**) and enters into the passageway of the second funnel (**835**). In essence, the flow booster (**800**) is designed with two venturi systems to increase the airflow into the filter system of the present invention thereby increasing the amount of bimolecular oxygen produced. As shown in FIG. **6**, the flow booster can be attached to a fan motor so as to provide airflow in addition to airflow exhaled from the patient. A second flow booster (not shown) can be positioned retrograde to the first of FIG. **6** to also increase the flow of air according to the same principal.

[0095] FIG. **11** is an exploded prospective view of the flow booster of the present invention (**900**) that shows the flow booster body (**825**) with a separate flow booster cap (**910**) that can be positioned on the flow booster body (**825**) so as to provide the plurality of venturi conduits that may decrease or increase the flow of air volume and so alter the oxygen concentration of the inspired air as designed for the flow boosters function. The prospective view (**900**) also shows the outflow nozzle (**820**) of the second funnel (**835**) on one end and the inlet (**805**) of the first funnel (**835**) directly across on the opposite end. The cap (**910**) containing multiple venturi holes fits on top of the flow booster body (**825**) and connects with the venture conduits beneath said cap (shown in FIG. **10**) so as to allow additional or diminished air to be drawn into the second funnel as described above.

[0096] The above structures can either be used to provide bimolecular oxygen and/or oxygen to an industrial device or to a patient. FIG. **12** shows a front view of a patient-breathing device (**1000**) using the technology of the present invention. The breathing device (**1000**) comprises a nasal shell (**1005**) designed to fit over the nose of a patient so as to gather exhaled air and provide oxygenated air to the patient. The nasal shell (**1005**) is attached to an above the lip support (**1010**) that is configured to properly position the device so as to maximize breathing capacity. The support (**1010**) is attached to an airflow tube (**1045**) that provides exhaled air to the filter device and receives oxygenated air for breathing from the filtering device. The airflow tube (**1045**) is in fluid communications with the casing (**1070**) containing the filtering device. The casing is attached to an overflow tube (**1025**) that captures overflow gases from the diRuthenium/zeolite-filtering device (**1030**) of the present invention. The flow booster (**1040**) is attached to the diRuthenium/zeolite filtering device (**1030**) within the casing (**1070**). Attached to the end of the flow booster (**1040**) is a fan motor (**1035**) designed to provide additional airflow to the flow booster (**1040**) of the present invention.

[0097] The patient breathing device (**1000**) shown in FIG. **12** is configured to funnel both exhaled air, air from a fan motor (**1035**) as well as additional air form the surroundings via the venturi system in the flow booster (**1040**) to the filtering device (**1030**). As the air flows into the filtering device that comprises the components discussed throughout the specification and shown in the figures aid in the splitting of water to produce bimolecular oxygen and hydrogen. That is water is split by the diRuthenium/zeolite filters and is funneled to the patient via the airflow tube (**1045** shown in FIG. **13**) in conjunction with the nasal shell (**1005**).

[0098] FIG. **13** shows a side view of the patient-breathing device (**1100**) that in addition to the nasal shell (**1005**), the support (**1010**), airflow tube (**1045**), and the filter casing (**1070**) shows a wide funnel (**1060**) that feeds oxygenated airflow to the patient. This wide funnel (**1060**) is feed oxygenated air from the filtering system of the invention via the outflow tube (**1025**) that captures oxygen and hydrogenated air produced from the filtering system (**1030**) of the present invention. Alternative configurations of the nasal shell and filter casing are possible and are envisioned to fall within the scope of the invention as long as proper airflow to and from the patient can be achieved.

[0099] The present invention is also directed to a method for producing bimolecular oxygen and/or hydrogen by providing a flow of air into a mouth area and/or a flow booster of one of the embodiments of the invention described above so that the filtering system also described above produces bimolecular oxygen and/or hydrogen gas to a patient in need therefore.

[0100] While the above description contains many specifics, these specifics should not be construed as limitations of the invention, but merely as exemplifications of preferred embodiments thereof. Those skilled in the art will envision many other embodiments within the scope and spirit of the invention as defined by the claims appended hereto.

1. An apparatus for producing oxygen and/or hydrogen gas from a source comprising;

a tubular and solid frame having an area configured to accommodate a cartridge; said cartridge configured to accommodate a filter material comprising a plurality of repeating units, said repeating unit comprising:

a porous boron doped carbon film comprising diRuthenium/diRuthenium molecules and at least one type of electronegative ion, said diRuthenium/diRuthenium molecules and said electronegative ions in direct contact with said porous boron doped carbon film, said porous boron doped carbon film further comprising a nanocarbon tubular mesh network and a Ruthenium ion capturing siderophore plate connected to the opposite surface of said porous boron doped carbon film in which said at least one diRuthenium/diRuthenium molecule is attached, said siderophore plate ionically charged so as capture free Ruthenium ions that become dislodged from said porous boron doped carbon film;

a synthetic film comprising a plurality of nanocarbon tubules attached and/or embedded on a surface of said synthetic film to form a nanocarbon tubule mesh network and at least one zeolite crystalline body in direct contact with said nanocarbon tubules wherein said synthetic film comprises a multiplicity of pores having a diameter of about 0.1 to about 3.0 nm and said zeolite crystalline attached to said nanocarbon tubules overlap at least part of said pores and said synthetic film positioned in close communication with said surface of said porous boron doped carbon film comprising said siderophore.

2. The apparatus for producing oxygen and/or hydrogen gas of claim **1** wherein said frame further comprises a mouthpiece.

3. The apparatus for producing oxygen and/or hydrogen gas of claim **2** further comprising a flow booster, said flow booster comprising a first and second nozzle positioned within each other and within an enclosure, said first and second nozzles open at both ends and having a wide end tapering to a narrower end, said wide end of said first and second nozzles in communication with a fan; and

said enclosure having a plurality of holes above said first and second nozzles whereby drawing additional air into said flow booster due to a Venturi effect created as air exits said first nozzle into said second nozzle.

4. The apparatus for producing oxygen and/or hydrogen gas of claim **1** wherein said frame further comprises a bifurcated accelerator having a flap valve and at least two junctions,

said first junction in communication with said mouthpiece and said second junction in communication with a flow booster, and

said flap valve having a first and second position, whereby when said flap valve is in said first position a first leg of said bifurcated accelerator is closed and a second leg is open and when said flap valve is in said second position said second leg of said bi-furcated accelerator is closed and said first leg is open.

5. The apparatus for producing oxygen and/or hydrogen gas of claim **4** further comprising a plurality of blow-by accelerator ports in communication with said frame so that air from said blow-by accelerator ports flows over said porous boron doped carbon film; and

a plurality of scavenger ports in communication with said frame and positioned across from said plurality of blow-by accelerator ports whereby a combination of un-reacted air flow and by-products from said blow-by accelerator ports that flows over said porous boron doped carbon film is captured by said scavenger ports and channeled into said frame to be used and/or vented out of said apparatus.

6. The apparatus for producing oxygen and/or hydrogen gas of claim **4** wherein said flap valve is positioned at a branching point of said bi-furcated accelerator.

7. The apparatus for producing oxygen and/or hydrogen gas of claim **6** wherein said blow-by accelerator ports have a wide end attached to said frame and a narrower end positioned at least partially over said porous boron doped carbon film so that air from said blow-by accelerator ports flows over said porous boron doped carbon film.

8. The apparatus for producing oxygen and/or hydrogen gas of claim **7** wherein said scavenger ports have a narrow end attached to said frame and a wide end positioned at least partially over said porous boron doped carbon film so that un-reacted air flow and by-products from said blow-by accelerator ports is captured by said scavenger ports and channeled into said frame to be used and/or vented out of said apparatus.

9. The apparatus for producing oxygen and/or hydrogen gas of claim **6** wherein said mouthpiece and said first junction is connected by a hollow tube configured to amplify channeled air from said mouthpiece to said branching point of said bi-furcated accelerator to actuate said flap valve.

10. The apparatus for producing oxygen and/or hydrogen gas of claim **9** wherein said flap valve is a pneumatic valve actuated by air and wherein said hollow tube is a fluidic amplifier configured to amplify air from said mouthpiece so as to provide sufficient air flow to actuate said pneumatic flap valve.

11. The apparatus for producing oxygen and/or hydrogen gas of claim **10** wherein one diRuthenium molecule of each said diRuthenium/diRuthenium molecule of said porous boron doped carbon film of said repeating units has the following formula (I):

$$[Ru_2(CO)_4(u\text{-}n^{2-}O_2CR)_2L_2]_x \tag{I}$$

wherein u is a bridging ligand selected from the group consisting of $[Ru_2(EDTA)_2]^{2-}$, $(CO)_4$, F^-,$Co_3{}^{-2}$, NO^+ (Cationic), Hydrogen-bonded aromatic/carboxylic Acid—(either for multiple attachments as polymerization or singular, at the double bonded Oxygen or sites within), ethylenediamine, halides as anionic ligands, carboxylic acid, unsaturated hydrocarbons, Nitric Acid coordinating to a metal center either linear or bent, butadiene, carboxylate ligands, anionic (RO— and RCO_2^{-2} (wherein R is H or hydrocarbon) or neutral ligands (R_2, R_2S, CO, CN^-), CH_3CN (Acetonitrile), NH_3 (Ammonia amine) F^-, Cl^-, tris(pyrazolyl)borates and mixtures thereof, preferably $[Ru_2(EDTA)_2]^{2-}$;

wherein n is at least 2 and depends on the denticity of the molecule—(that is, the number of donor groups from a given ligand attached to the same central atom);

wherein L is a ligand selected from the group consisting of $[Ru_2(Ph_2PCH_2CH_2PPh_2)(EDTA)]^{2+}$, C_6H_6, $R_2C{=}CR_2$ (wherein R is H or an alkyl), 1,1-Bisdiphenylphosphino methane, diethylenetriamine [diene] bonds preferably tridentate, triazacyclononane [diene] bonds preferably tridentate, triphenylphosphine and mixtures thereof;

wherein CR is carboxylic acid, carboxylate ligands, anionic (RO^- and RCO_2^- (wherein R is an alkyl group)) or neutral ligands (R_2,R_2S, CO^-, CN^- (wherein R is an alkyl group)) and mixtures thereof; and

x is between 1 and about 30.

12. The apparatus for producing oxygen and/or hydrogen gas of claim **11** wherein one diRuthenium of said diRuthenium/diRuthenium molecules of formula (I) is attached to a diRuthenium-substituted polyoxometalate having the following formula (II)

$$[WZnRu^{III}_2(OH)(H_2O)(ZnW_9O_{34})_2] \qquad (II).$$

13. The apparatus for producing oxygen and/or hydrogen gas of claim **1** wherein said siderophore plate is selected from the group consisting of a polysulfinate resin impregnated plate, ethylenediaminetetraacetic acid (EDTA) and mixtures thereof.

14. The apparatus for producing oxygen and/or hydrogen gas of claim **12** wherein the distance between each Ruthenium in said diRuthenium/diRuthenium is about 2.75 angstroms.

15. The apparatus for producing oxygen and/or hydrogen gas of claim **12** wherein said nanotubules of said nanocarbon tubular mesh network have a diameter of about 20 nanometers to about 450 nanometers.

16. The apparatus for producing oxygen and/or hydrogen gas of claim **12** wherein said synthetic film is SiO_4, AlO_4, and mixtures thereof.

17. The apparatus for producing oxygen and/or hydrogen gas of claim **16** wherein said nanocarbon tubular mesh network embedded on said surface of said synthetic film extends about 0.2 to about 5 millimeters above said surface.

18. The apparatus for producing oxygen and/or hydrogen gas of claim **12** wherein said nanocarbon tubular mesh network is arranged in concentric spaced circles starting form a center region of said porous boron doped carbon film outwards.

19. The apparatus for producing oxygen and/or hydrogen gas of claim **12** wherein nanocarbon tubules embedded on said surface of said zeolite containing synthetic film is arranged in concentric spaced circles starting form a center region of said porous boron doped carbon film outwards.

20. The apparatus for producing oxygen and/or hydrogen gas of claim **1** wherein said cartridge is removable from said apparatus and further comprises an insert for a removable cartridge case, said cartridge case configured to have a plurality of slots and a void extending from one side of said cartridge case to the other wherein said plurality of slots are configured to accommodate said repeating units and said void is configured so as to leave at least a portion of said filter material exposed to said source.

21. The apparatus for producing oxygen and/or hydrogen gas of claim **12** wherein said diRuthenium-substituted polyoxometalate of formula (II) is $Na_{14}[Ru_2Zn_2(H_20)_2(ZnW_9O_{34})_2]$.

22. The filter material of claim **21** wherein said diRuthenium-substituted polyoxometalate of formula (II) is $Na_{14}[Ru_2Zn_2(H_20)_2(ZnW_9O_{34})_2]$.

23. A breathing device comprising said apparatus for producing oxygen and/or hydrogen gas of claim **1**.

24. The apparatus for producing oxygen and/or hydrogen gas of claim **11** wherein formula (I) is bonded to either an anionic chemical selected from the group consisting of $Ru^{(III)}(CN)_6^{-3}$, PO_4^{-3}, F and mixtures thereof or a cationic form of diRuthenium complex of hexamethylene tetramine having the formula $\{Ru_2[N(CH_2NH_2)_3]^{6+}\}_2Ru_2[N(CH_2NH_2)_3]^{6+}\}$.

25. The apparatus for producing oxygen and/or hydrogen gas of claim **12** wherein formula (II) is converted to $Ru_2Zn_2(H_20)_2(ZnW_9)_{34})_2^{-14}$.

26. The apparatus for producing oxygen and/or hydrogen gas of claim **21** wherein said $Na_{14}[Ru_2Zn_2(H20)_2(ZnW_9O_{34})_2]$ is converted to $Ru_2Zn_2(H_2O)_2(ZnW_9O_{34})_2^{-14}$ or to $Ru_2Zn_2(H_20)_2(ZnW_9)_{34})_2^{-14}$.

27. A method for producing bimolecular oxygen and/or hydrogen comprising:

providing a flow of air into said mouthpiece and/or flow booster of claim **5** in said apparatus for producing oxygen and/or hydrogen gas of claim so as to produce a flow of oxygen and/or hydrogen gas from said apparatus.

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