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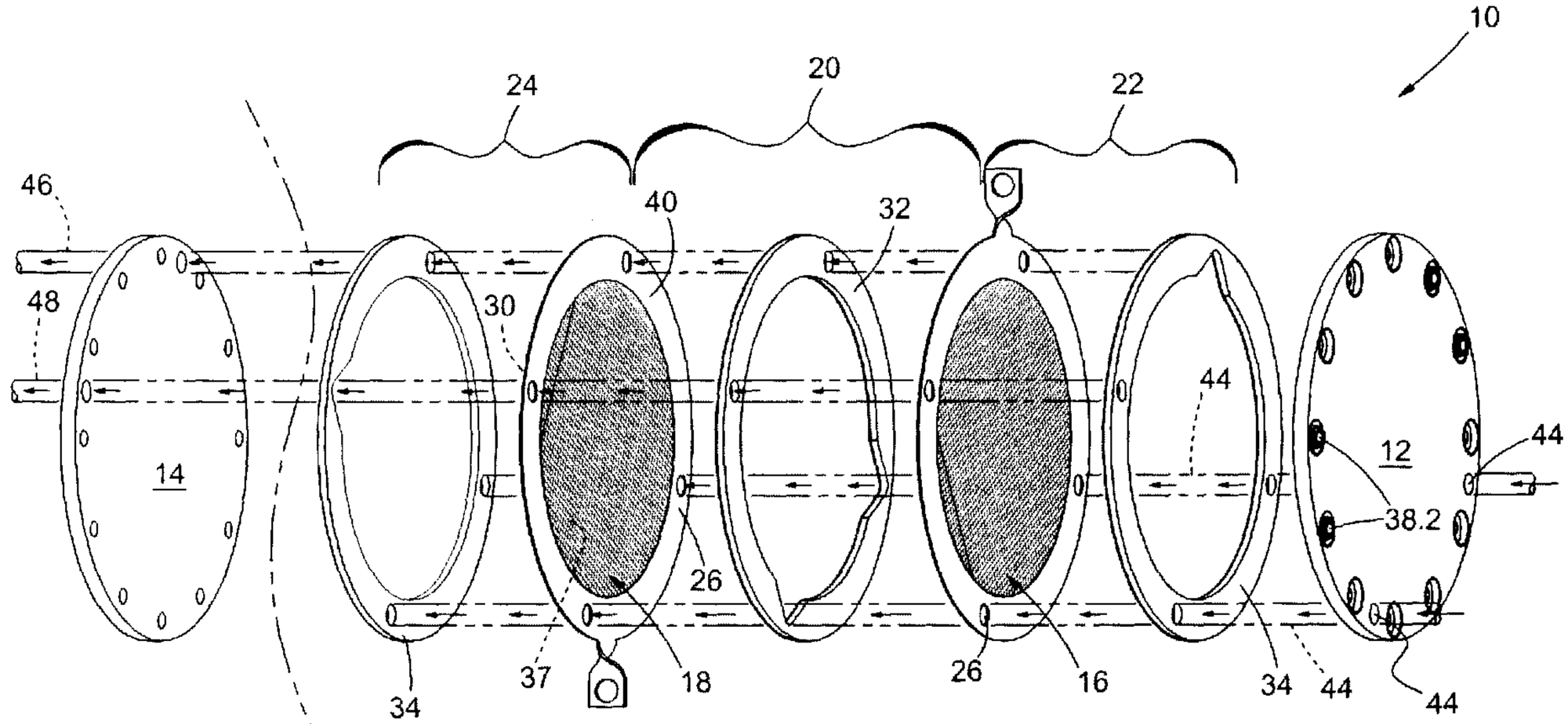

FIGURE 1

(57) Abrégé/Abstract:
This invention relates to an electrolysis method and electrolysis apparatus (10) for producing oxygenated and hydrogenated fluid. The apparatus (10) comprises first and second outer end members (12 and 14), both being of polyethylene and at least two spaced apart permeable electrodes (16 and 18). The permeable electrode (16 and 18) are each of a foraminous or perforated material, such as nickel foam sheet material. The two permeable electrodes (16 and 18) are arranged generally parallel to one another and are relatively closely spaced from one another. An inlet chamber (20) is therefore defined between the first and second permeable electrodes (16 and 18). A first oxygenated fluid collection chamber (22) is disposed between the first permeable electrode (16) and the first end member (12) and a second hydrogenated fluid collection chamber (24) is disposed between the second permeable electrode (18) and the second end member (14).

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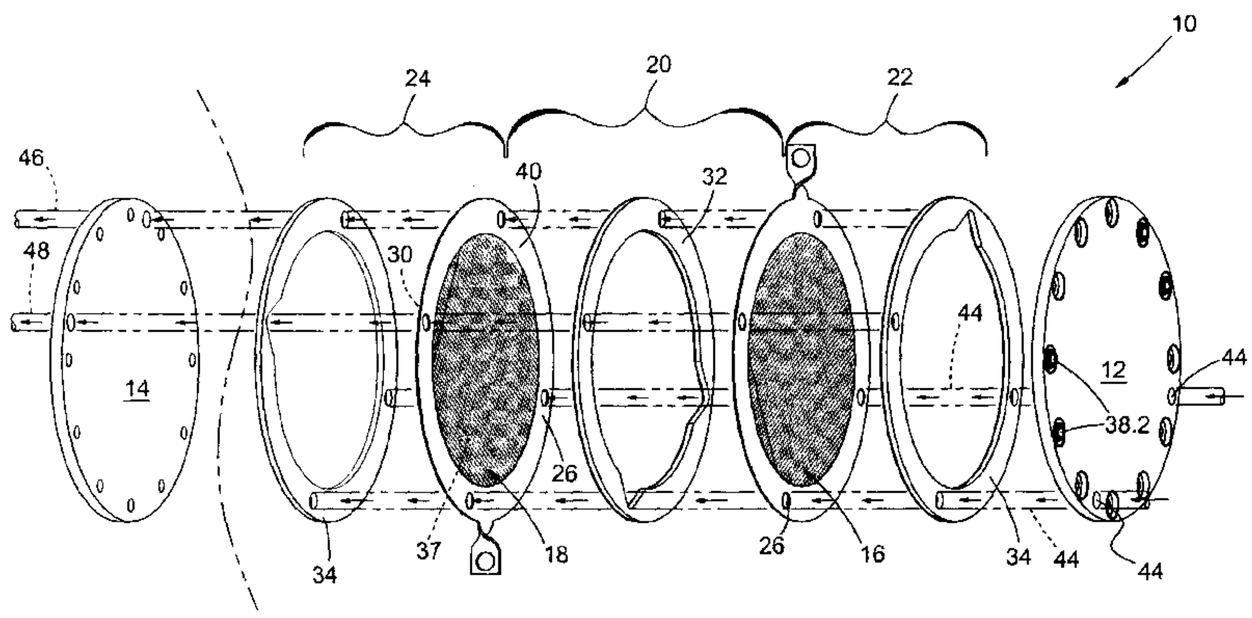

FIGURE 1

(57) **Abstract**: This invention relates to an electrolysis method and electrolysis apparatus (10) for producing oxygenated and hydrogenated fluid. The apparatus (10) comprises first and second outer end members (12 and 14), both being of polyethylene and at least two spaced apart permeable electrodes (16 and 18). The permeable electrode (16 and 18) are each of a foraminous or perforated material, such as nickel foam sheet material. The two permeable electrodes (16 and 18) are arranged generally parallel to one another and are relatively closely spaced from one another. An inlet chamber (20) is therefore defined between the first and second permeable electrodes (16 and 18). A first oxygenated fluid collection chamber (22) is disposed between the first permeable electrode (16) and the first end member (12) and a second hydrogenated fluid collection chamber (24) is disposed between the second permeable electrode (18) and the second end member (14).

METHOD AND APPARATUS FOR PRODUCING GAS

FIELD OF THE INVENTION

This invention relates to a method and apparatus for producing gas. More particularly, but not exclusively, this invention relates to an electrolysis cell and method in which combustible gasses, such as hydrogen gas and oxygen gas are produced through the electrolysis of an aqueous electrolytic solution and are kept separate upon production.

BACKGROUND TO THE INVENTION

An electrolysis cell uses electricity to convert water to hydrogen and oxygen in gas phase. A known electrolysis cell includes a proton exchange membrane in order to separate the hydrogen and oxygen gases produced through the electrolysis process. The electrolysis cell further includes an anode positioned along a first face of the proton exchange membrane and a cathode positioned along a second opposite face of the proton exchange membrane.

A known proton exchange membrane is a semi-permeable membrane generally made from ionomers and designed to conduct protons while being impermeable to gases, such as oxygen and hydrogen. Proton exchange membranes can be made from either pure polymer membranes or from

composite membranes where other materials are embedded in a polymer matrix.

A first disadvantage of the known proton exchange membrane is the high cost of the membrane, since it requires that a noble-metal catalyst (typically platinum) be used to separate the hydrogen's electrons and protons. The platinum catalyst is also extremely sensitive to carbon monoxide poisoning, making it necessary to employ an additional reactor to reduce carbon monoxide in the fuel gas if the hydrogen is derived from an alcohol or hydrocarbon fuel. This again adds to the cost of using the known proton exchange membrane.

Further disadvantages of the know proton exchange membranes are their poor conductivity at lower relative humidity and their poor mechanical properties at temperatures above approximately 100 °C. The operating temperature of these membranes is relatively low and temperatures near 100 °C are not high enough to perform useful cogeneration.

Another disadvantage of the known proton exchange membranes is that their efficiency goes down as the voltage applied across the cell goes up, due to poor gas removal from the membrane. Also, the electrodes cannot be stacked too close together, as this will inhibit gas removal from the membrane.

In this specification, the term "combustible fluid" includes within its scope combustible gas containing predominantly hydrogen and/or oxygen in gas phase.

OBJECT OF THE INVENTION

It is accordingly an object of the present invention to provide a method and apparatus for producing gas, with which the above disadvantages may be overcome and which are useful alternatives to known electrolysis cells and methods for producing gas.

SUMMARY OF THE INVENTION

According to a first aspect of the invention there is provided a method for producing combustible fluid from an electrolytic solution during a process of electrolysis including the steps of:

- providing an electrolytic solution;
- providing an electrolysing apparatus having first and second spaced apart permeable electrodes, defining a chamber between them, having at least one inlet;
- passing the solution into the chamber via the inlet; and
- applying a voltage to the apparatus across the electrodes to electrolyse the solution in the chamber, so that a first combustible fluid forms on the first electrode and a second combustible fluid forms on the second electrode, and the first combustible fluid

passes out of the chamber via the first electrode and the second combustible fluid passes out of the chamber via the second electrode.

The combustible fluid may be hydrogenated and oxygenated fluid and more specifically the combustible fluid may be hydrogen and oxygen gas.

The permeable electrodes may each be perforated or foraminous.

Each permeable electrode may further be of a mesh or foam material.

Each permeable electrode may be made of a 316 stainless steel or nickel material.

The first and second electrodes may be provided in relative close proximity to one another and may be substantially parallel.

The first and second permeable electrodes may have a correct and predetermined ratio of open to closed area (also known as the PPI (pores per square inch)), which may be influenced by the size of the inlet and the pressure of the solution being provided to the apparatus.

The first and second permeable electrodes may be one set of permeable electrodes and the apparatus may include a plurality of sets of permeable electrodes, all having a similar configuration.

The electrolysing apparatus may define at least one inlet passage in fluid flow communication with all of the inlets and the method may include the step of passing the solution into the chambers of all of the sets of permeable electrodes via the inlet passage.

The first combustible fluid outlet passage may be in fluid flow communication with all of the first combustible fluid outlets of all of the sets of permeable electrodes and the second combustible fluid outlet passage may be in fluid flow communication with all of the second combustible fluid outlets of all of the sets of permeable electrodes, the arrangement being such that the first combustible fluid formed on the first electrode passes out of the apparatus via the first combustible fluid outlet passage and the second combustible fluid formed on the second electrode passes out of the apparatus via the second combustible fluid outlet passage.

According to a second aspect of the invention there is provided an electrolysing apparatus in which combustible fluid is produced from an electrolytic solution in a process of electrolysis comprising:

- first and second spaced apart permeable electrodes defining an inlet chamber between them;
- at least one inlet into the inlet chamber for passing the electrolytic solution into said inlet chamber;
- a first combustible fluid chamber on a first side of the set of electrodes and a second combustible fluid chamber on a second side of the set of electrodes; and
- a first combustible fluid outlet from the first combustible fluid chamber and a second combustible fluid outlet from the second combustible fluid chamber;

the arrangement being such that the electrolytic solution passes into the inlet chamber via the inlet where electrolysis takes place; and such that a first combustible fluid forms on the first electrode; and such that a second combustible fluid forms on the second electrode; and further such that the first combustible fluid passes through the first electrode into the first combustible fluid chamber; and such that the second combustible fluid passes through the second electrode into the second combustible fluid chamber; and such that the first combustible fluid passes out the first combustible fluid chamber via the first combustible fluid outlet; and the second combustible fluid passes out the second combustible fluid chamber via the second combustible fluid outlet.

The combustible fluid may be hydrogenated and oxygenated fluid and more specifically the combustible fluid may be hydrogen and oxygen gas.

The permeable electrodes may each be perforated or foraminous.

Each permeable electrode may further be of a mesh or foam material,

Each permeable electrode may be made of a 316 stainless steel or nickel material.

The first and second electrodes may be provided in relative close proximity to one another and may be substantially parallel.

The first and second electrodes may each include at least one connector tab for connecting to a power supply to supply a voltage over the electrolysing apparatus to electrolyse the electrolytic solution.

The first and second electrodes may incorporate a solid outer ring for the purpose of fluid sealing, attachment of the connection tab, and distribution of current around the electrode.

The first and second permeable electrodes may have a correct and predetermined ratio of open to closed area (also known as the PPI (pores per

square inch)), which may be influenced by the size of the inlet and the pressure of the solution being provided to the apparatus.

The electrolysing apparatus may include a gasket positioned in the peripheral region between the two electrodes forming the set of electrodes.

The gasket may be a first gasket and the electrolysing apparatus may include a plurality of second gaskets, each positioned in the peripheral region between adjacent sets of electrodes.

The apparatus may include first and second outer end members, each being of polyethylene.

The apparatus may be cylindrical or multi-agonal in shape.

The apparatus may include circulating means, such as a pump, to circulate the solution through the apparatus and to force the solution into the first chamber.

The first combustible fluid outlets may be aligned to define a first combustible fluid outlet passage, so that first combustible fluid produced in all of the first combustible fluid chambers passes out of the apparatus via the first combustible fluid outlet passage.

The second combustible fluid outlets may be aligned to define a second combustible fluid outlet passage, so that second combustible fluid produced in all of the second combustible fluid chambers passes out of the apparatus via the second combustible fluid outlet passage.

The apparatus may include a first combustible fluid collection container connected to the first combustible fluid outlet passage and a second combustible fluid collection container connected to the second combustible fluid outlet passage.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described further by way of a non-limiting example with reference to the accompanying drawings wherein:

figure 1 is an exploded perspective view of part of an electrolysis apparatus according to a preferred embodiment of the invention; and

figure 2 is a perspective view of the electrolysis apparatus of figure 1.

DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

Referring to the drawings, an electrolysis apparatus according to a preferred embodiment of the invention is generally designated by reference numeral 10.

The electrolysis apparatus 10 is adapted to produce oxygenated and hydrogenated fluid, formed during the electrolysis of an electrolytic solution passed into the apparatus 10.

The apparatus 10 comprises a first outer end member 12, being of polyethylene, and a second outer end member 14, also being of polyethylene. The first and second outer end members 12 and 14 are both disc shaped and are arranged generally parallel to one another and are spaced from one another. It is foreseen that the apparatus could be multi-agonal in shape and not necessarily cylindrical or circular.

The apparatus 10 further includes two spaced apart permeable electrodes, a first permeable electrode 16 and a second permeable electrode 18. The permeable electrode 16 and 18 are each of a foraminous or perforated material. Specifically the permeable electrodes are each of nickel foam sheet, but could also be 316 stainless steel. The two permeable electrodes 16 and 18 are also arranged generally parallel to one another, are relatively closely spaced from one another. An inlet chamber 20 is therefore defined

between the first and second permeable electrodes 16 and 18. A first oxygenated fluid collection chamber 22 is disposed between the first permeable electrode 16 and the first end member 12 and a second hydrogenated fluid collection chamber 24 is disposed between the second permeable electrode 18 and the second end member 14.

The closer the permeable electrodes 16 and 18 are spaced to each other, results in a lower resistance between them, which means less voltage needs to be applied to the apparatus 10, which results in a more efficient apparatus 10.

The inlet chamber 20 has two inlets 26 for allowing electrolytic solution to pass into said chamber 20. The oxygen and hydrogen collection chambers 22 and 24 are each provided with a fluid outlet. The oxygen collection chamber 22 is provided with an oxygen outlet 28 and a hydrogen collection chamber 24 is provided with a hydrogen outlet 30.

The flow of electrolytic solution through the permeable electrodes 16 and 18 will carry with it the oxygen and hydrogen gasses generated on the positive and negative (first and second) permeable electrodes respectively. There is thus a natural separation of the hydrogen and oxygen gasses. The close proximity of the electrodes 16 and 18 also permits hydrolyzing at very low voltage, permitting high efficiency and high purity hydrogen and oxygen.

The first and second permeable electrodes 16 and 18 defining first chamber 20 between them forms a set of permeable electrodes. The apparatus 10 could include a plurality of sets of permeable electrodes arranged and connected to one another in a back-to-front arrangement. Figures 2 and 3 shows the apparatus 10 including 3 sets of permeable members between the first and second outer electrodes 12 and 14.

The apparatus includes a plurality of intermediate barrier members 42, positioned between adjacent sets.

The electrolysing apparatus 10 further includes an inlet ring 32 defining the two inlets 26 and outlet rings 34 defining the oxygen outlet 28 and hydrogen outlet 30 respectively, located on opposite sides of the two permeable electrodes 16 and 18. The inlet ring 32 is positioned in the peripheral region and between the first and second permeable electrodes 16 and 18 to seal the two electrodes 16 and 18 to one another and the outlet rings 34 are positioned in the peripheral region on the opposite sides of the permeable electrodes 16 and 18.

The first and second electrodes 16 and 18 include conductive connector tabs (one being the positive terminal and the other being the negative terminal) for connecting to a power supply (not shown), such as a battery. The powers

supply thus supplies a voltage of between 1 V and 6 V, over the electrolysing apparatus 10 to electrolyse the solution. The present apparatus 10 produces hydrogen and oxygen by applying either a pure DC voltage or pulsed DC voltage to the apparatus.

Corresponding inlets 26 of the inlet rings of the apparatus 10 are aligned to define inlet passages 44, so that electrolytic solution is passed into all of the chambers 20 of the apparatus 10 via the inlet passages 44. The oxygen outlets 28 are also aligned to define an oxygen outlet passage 46, so that oxygenated fluid accumulated in all of the oxygen collection chambers 22 passes out via the oxygen outlet passage 46. Similarly, the hydrogen outlets 30 are also aligned to define a hydrogen outlet passage 48, so that hydrogenated fluid accumulated in all of the hydrogen collection chambers 24 passes out via the hydrogen outlet passage 48.

The apparatus 10 further includes a circulating means, such as a pump (not shown) to circulate the solution through the apparatus 10. The electrolytic solution flowing into the chamber 20 via the inlets 26 is pressurised by being pumped into the apparatus 10 by the pump, so that the solution is forced through the permeable electrodes 16 and 18 into the hydrogen and oxygen collection chambers 22 and 24. The arrangement is such that electrolytic solution flows into the first chamber 20 via the inlets 26, through the permeable electrodes 16 and 18 into the oxygen and hydrogen collection

chambers 22 and 24 respectively. Electrolytic action takes place between the first and second permeable electrodes 16 and 18 respectively. The oxygenated fluid passes out of the oxygen collection chamber 22 via the oxygen outlet 28 and the hydrogenated fluid passes out of the hydrogen collection chamber 24 via the hydrogen outlet 30.

The apparatus 10 could further include a hydrogen collection container (not shown) connected to the hydrogen outlet passage 48 and an oxygen collection container (also not shown) connected to the oxygen outlet passage 46. The oxygen and hydrogen collection containers each have a second electrolytic solution outlet located towards the operatively bottom end of the containers and oxygen and hydrogen gas outlets located towards the operatively top end of each of the oxygen and hydrogen collection containers, respectively. Electrolytic solution passes out of the oxygen and hydrogen outlets 28 and 30 from the oxygen and hydrogen collection chambers 22 and 24, together with the respective gases, into the oxygen and hydrogen collection containers via the outlet passages 46 and 48. The arrangement is such that hydrogen and oxygen gases within the fluids passing into the respective containers are released through gravitation and passed out of the containers via the oxygen and hydrogen gas outlets and the electrolytic solution passes out of the containers via the second electrolytic solution outlets. The second electrolytic solution outlets are connected to the inlet passages 44 and the solution is circulated back to the

apparatus 10 by means of the pump. The gasses are thus stored for later use.

It is foreseen that there is a positive flow from the first chamber 20 to the oxygen and hydrogen collection chambers 22 and 24 of the apparatus 10. The pressurised flow of the electrolytic solution from the first chamber 20 to the oxygen and hydrogen collection chambers 22 and 24, through the permeable electrodes, restricts oxygen gas and hydrogen gas, after formation on the first and second permeable electrodes 16 and 18 to enter the first chamber 20.

It is further foreseen that the electrolysis apparatus essentially does not have a membrane, as in the case of prior art apparatus. This has a number of advantages, for example, the cost of both a wet or dry membrane is removed, along with the cost of maintaining the membranes. It also removes the pressure and temperature limitations that are usually present with the use of membranes. In the present invention, permeable electrodes are used, which do not allow for shaded conduction areas to be created by the movement of gasses across the electrode surface. This increases the effective conduction area of the electrode, reduces the effective voltage requirement and thereby improves efficiency.

It will be appreciated that variations in detail are possible with a method and apparatus for producing hydrogen and oxygen gasses according to the invention without departing from the scope of the appended claims.

CLAIMS

1. A method for producing combustible fluid from an electrolytic solution during a process of electrolysis including the steps of: providing an electrolytic solution; providing an electrolysing apparatus having first and second spaced apart permeable electrodes, defining a chamber between them, having at least one inlet; passing the solution into the chamber via the inlet; and applying a voltage to the apparatus across the electrodes to electrolyse the solution in the chamber, so that a first combustible fluid forms on the first electrode and a second combustible fluid forms on the second electrode, and the first combustible fluid passes out of the chamber via the first electrode and the second combustible fluid passes out of the chamber via the second electrode.

2. A method according to claim 1 wherein the combustible fluid is hydrogenated and oxygenated fluid and more specifically the combustible fluid is hydrogen and oxygen gas.

3. A method according to claim 1 or 2 wherein the permeable electrodes are each perforated or foraminous.

4. A method according to claim 3 wherein each permeable electrode is of a mesh or foam material.

5. A method according to claim 4 wherein each permeable electrode is made of a 316 stainless steel or nickel foam material.

6. A method according to any one of the preceding claims wherein the first and second electrodes are provided in relative close proximity to one another and are substantially parallel.

7. A method according to claim 6 wherein the first and second permeable electrodes have a correct and predetermined ratio of open to closed area (also known as the PPI (pores per square inch)), which is influenced by the size of the inlet and the pressure of the solution being provided to the apparatus.

8. A method according to any one of the preceding claims wherein the first and second permeable electrodes are one set of permeable electrodes and the apparatus includes a plurality of sets of permeable electrodes, all having a similar configuration.

9. A method according to claim 8 wherein the electrolysing apparatus defines at least one inlet passage in fluid flow communication with all

of the inlets and the method includes the step of passing the solution into the chambers of all of the sets of permeable electrodes via the inlet passage.

10. A method according to claim 9 wherein the first combustible fluid outlet passage is in fluid flow communication with all of the first combustible fluid outlets of all of the sets of permeable electrodes and the second combustible fluid outlet passage is in fluid flow communication with all of the second combustible fluid outlets of all of the sets of permeable electrodes, the arrangement being such that the first combustible fluid formed on the first electrode passes out of the apparatus via the first combustible fluid outlet passage and the second combustible fluid formed on the second electrode passes out of the apparatus via the second combustible fluid outlet passage.

11. An electrolysing apparatus in which combustible fluid is produced from an electrolytic solution in a process of electrolysis comprising: first and second spaced apart permeable electrodes defining an inlet chamber between them; at least one inlet into the inlet chamber for passing the electrolytic solution into said inlet chamber; a first combustible fluid chamber on a first side of the set of electrodes and a second combustible fluid chamber on a second side of the set of electrodes; and a first combustible fluid outlet from the first combustible fluid

chamber and a second combustible fluid outlet from the second combustible fluid chamber, the arrangement being such that the electrolytic solution passes into the inlet chamber via the inlet where electrolysis takes place; and such that a first combustible fluid forms on the first electrode; and such that a second combustible fluid forms on the second electrode; and further such that the first combustible fluid passes through the first electrode into the first combustible fluid chamber; and such that the second combustible fluid passes through the second electrode into the second combustible fluid chamber; and such that the first combustible fluid passes out the first combustible fluid chamber via the first combustible fluid outlet; and the second combustible fluid passes out the second combustible fluid chamber via the second combustible fluid outlet.

12. An apparatus according to claim 11 wherein the combustible fluid is hydrogenated and oxygenated fluid and more specifically the combustible fluid is hydrogen and oxygen gas.

13. An apparatus according to claim 11 or 12 wherein the permeable electrodes are each perforated or foraminous.

14. An apparatus according to claim 13 wherein each permeable electrode is further of a meshed or foam material.

15. An apparatus according to claim 14 wherein each permeable electrode is made of a 316 stainless steel or nickel foam material.

16. An apparatus according to any one of claims 11 to 15 wherein the first and second electrodes are provided in relative close proximity to one another and are substantially parallel.

17. An apparatus according to any one of claims 11 to 16 wherein the first and second electrodes each include at least one connector tab for connecting to a power supply to supply a voltage over the electrolysing apparatus to electrolyse the electrolytic solution.

18. An apparatus according to claim 17 wherein the first and second electrodes incorporate a solid outer ring for the purpose of fluid sealing, attachment of the connection tab, and distribution of current around the electrode.

19. An apparatus according to claim any one of claims 11 to 16 wherein the first and second permeable electrodes have a correct and predetermined ratio of open to closed area (also known as the PPI (pores per square inch)), which is influenced by the size of the inlet and the pressure of the solution being provided to the apparatus.

20. An apparatus according to any one of claims 11 to 16 which includes a gasket positioned in the peripheral region between the two electrodes, forming a set of electrodes.

21. An apparatus according to claim 20 wherein the gasket is a first gasket and the electrolysing apparatus includes a plurality of second gaskets, each positioned in the peripheral region between adjacent sets of electrodes.

22. An apparatus according to any one of claims 11 to 21 which includes first and second outer end members, each being of polyethylene.

23. An apparatus according to any one of claims 11 to 22 which is cylindrical or multi-agonal in shape.

24. An apparatus according to any one of claims 11 to 23 which includes circulating means, such as a pump, to circulate the solution through the apparatus and to force the solution into the first chamber.

25. An apparatus according to claim 24 wherein the first combustible fluid outlets are aligned to define a first combustible fluid outlet passage, so that first combustible fluid produced in all of the first combustible fluid

chambers passes out of the apparatus via the first combustible fluid outlet passage.

26. An apparatus according to claim 25 wherein the second combustible fluid outlets are aligned to define a second combustible fluid outlet passage, so that second combustible fluid produced in all of the second combustible fluid chambers passes out of the apparatus via the second combustible fluid outlet passage.

27. An apparatus according to claim 26 which includes a first combustible fluid collection container connected to the first combustible fluid outlet passage and a second combustible fluid collection container connected to the second combustible fluid outlet passage.

28. A method for producing combustible fluid, substantially as herein described and as illustrated in the accompanying drawings.

29. An electrolysing apparatus in which combustible fluid is produced substantially as herein described and as illustrated in the accompanying drawings.

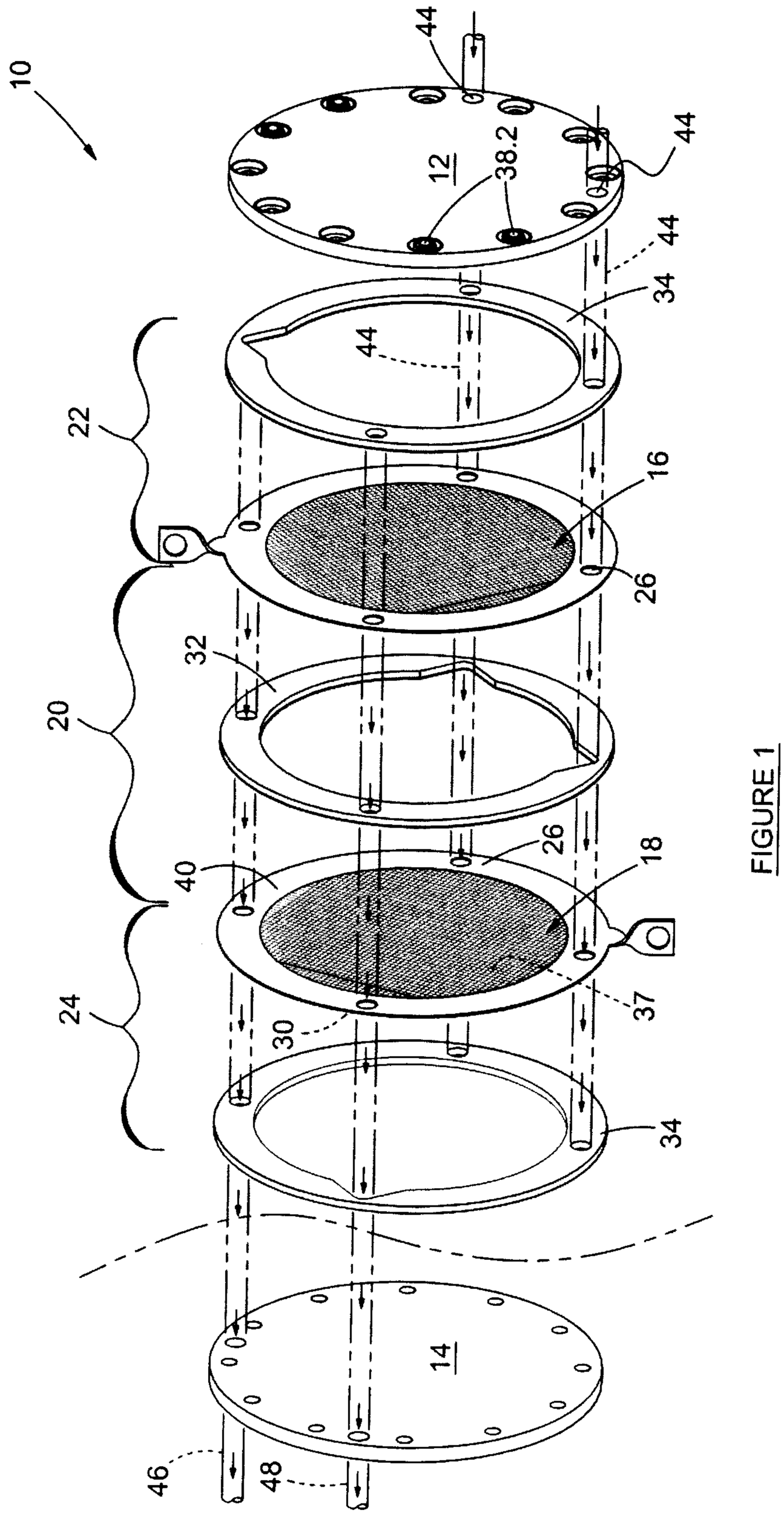

FIGURE 1

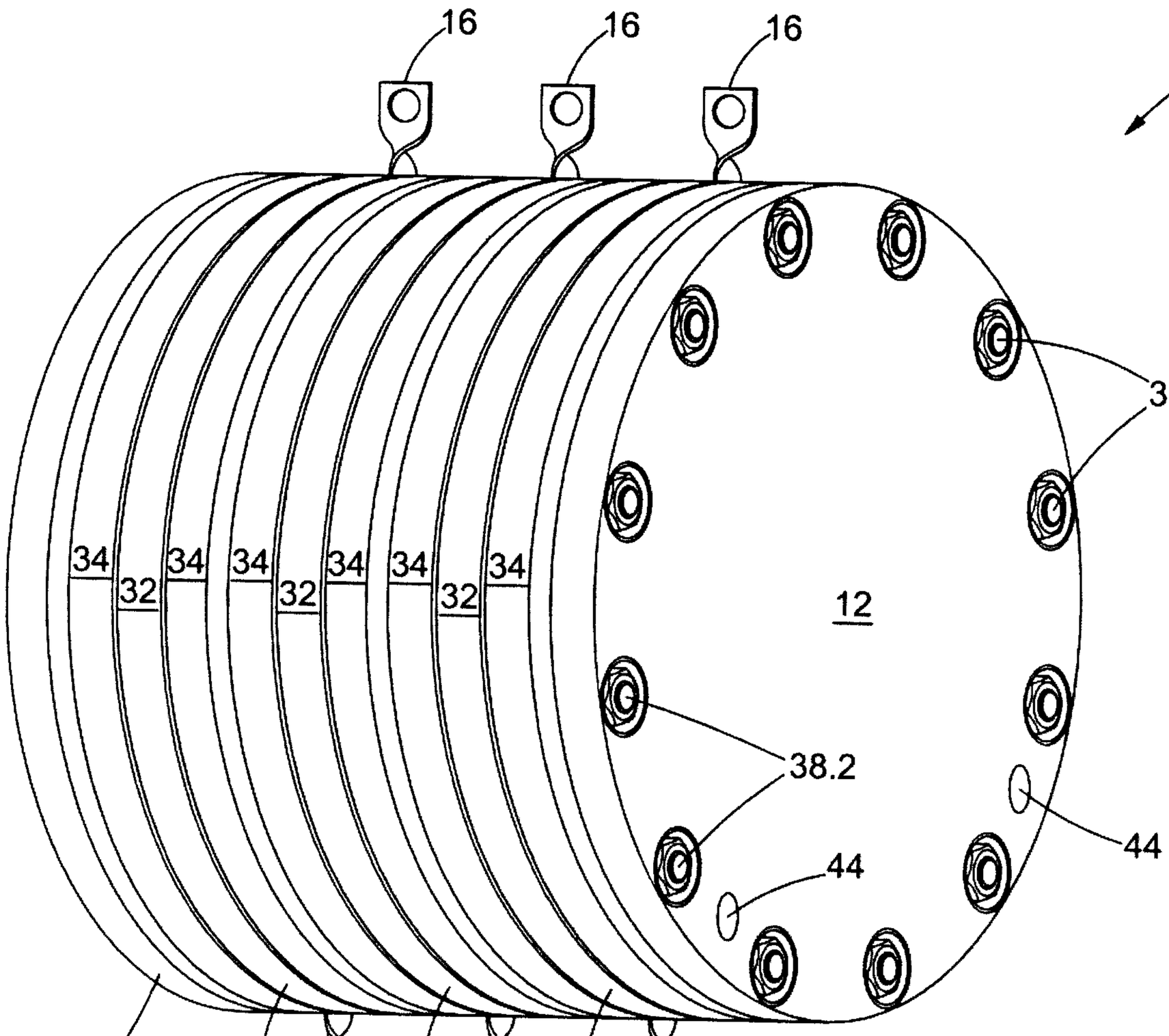
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FIGURE 2

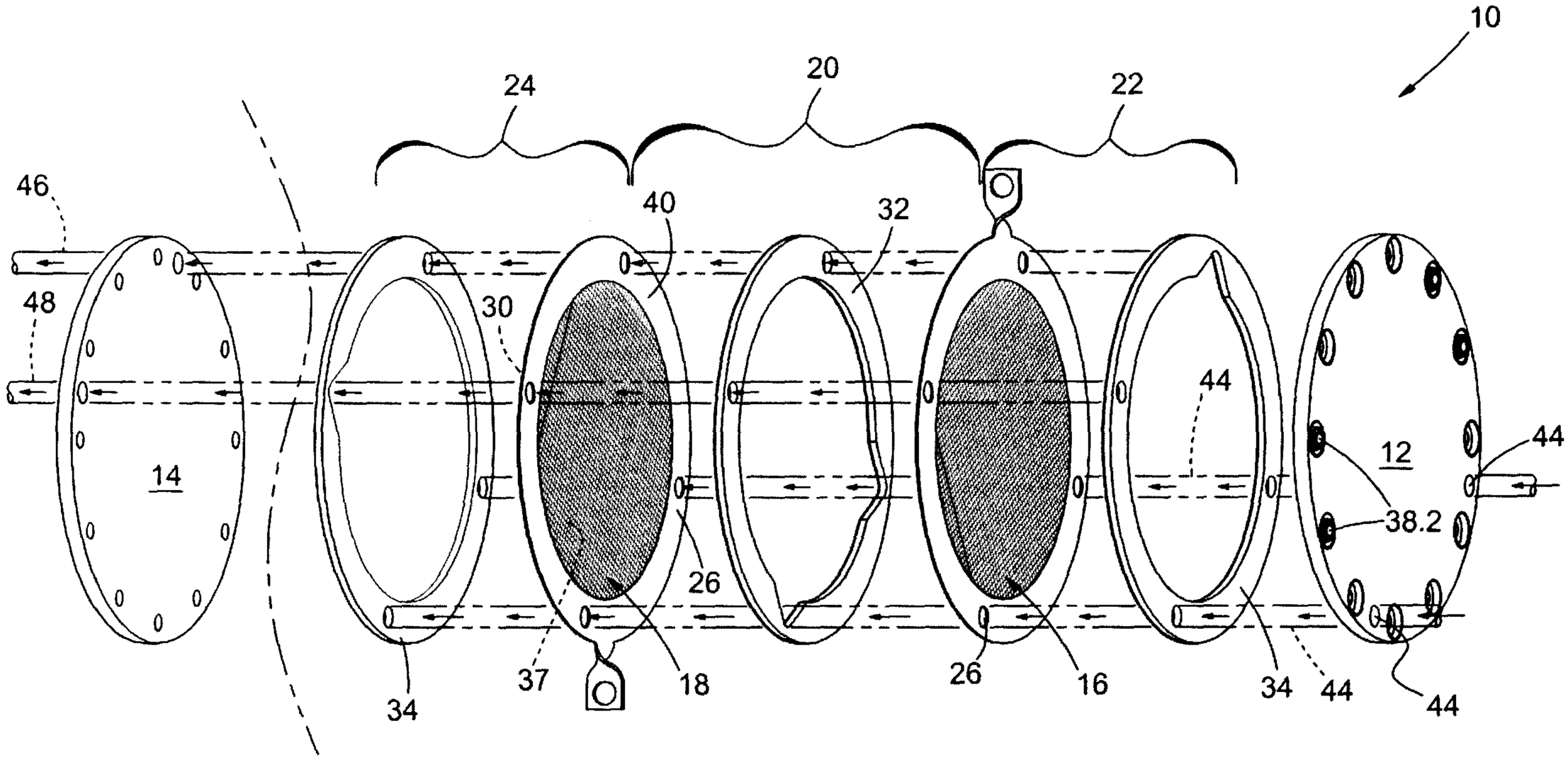

FIGURE 1