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(54) DISTRIBUTION FRAME FOR A FUEL CELL

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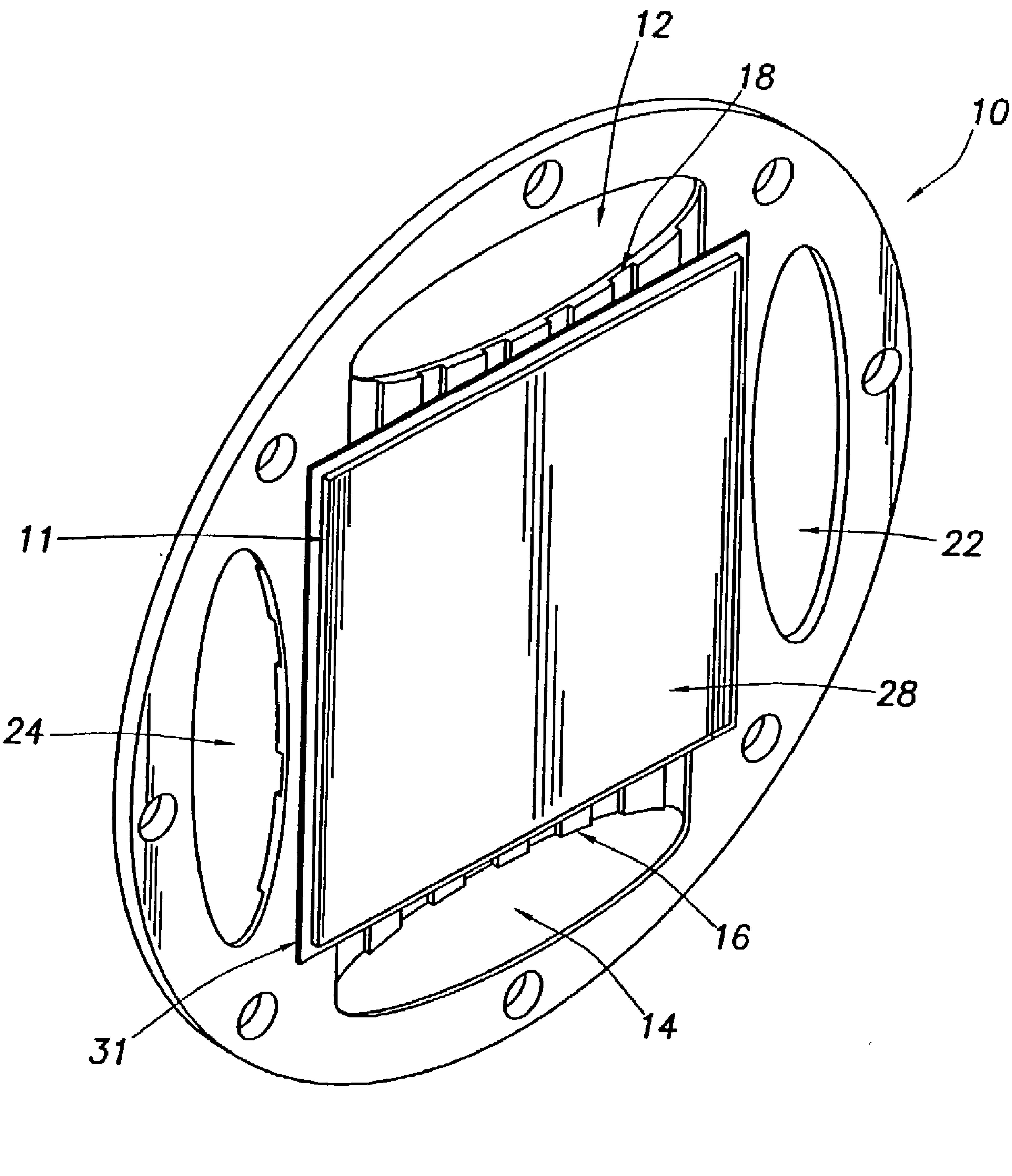
(57) ABSTRACT

The present invention comprises an improved flow field and reactant supply system, which provides improved and more efficient mass transport of the reactants to a fuel cell and thus the fuel cell stack assembly. The improved reactant supply system comprises an improved distribution frame adapted to house a fuel cell.



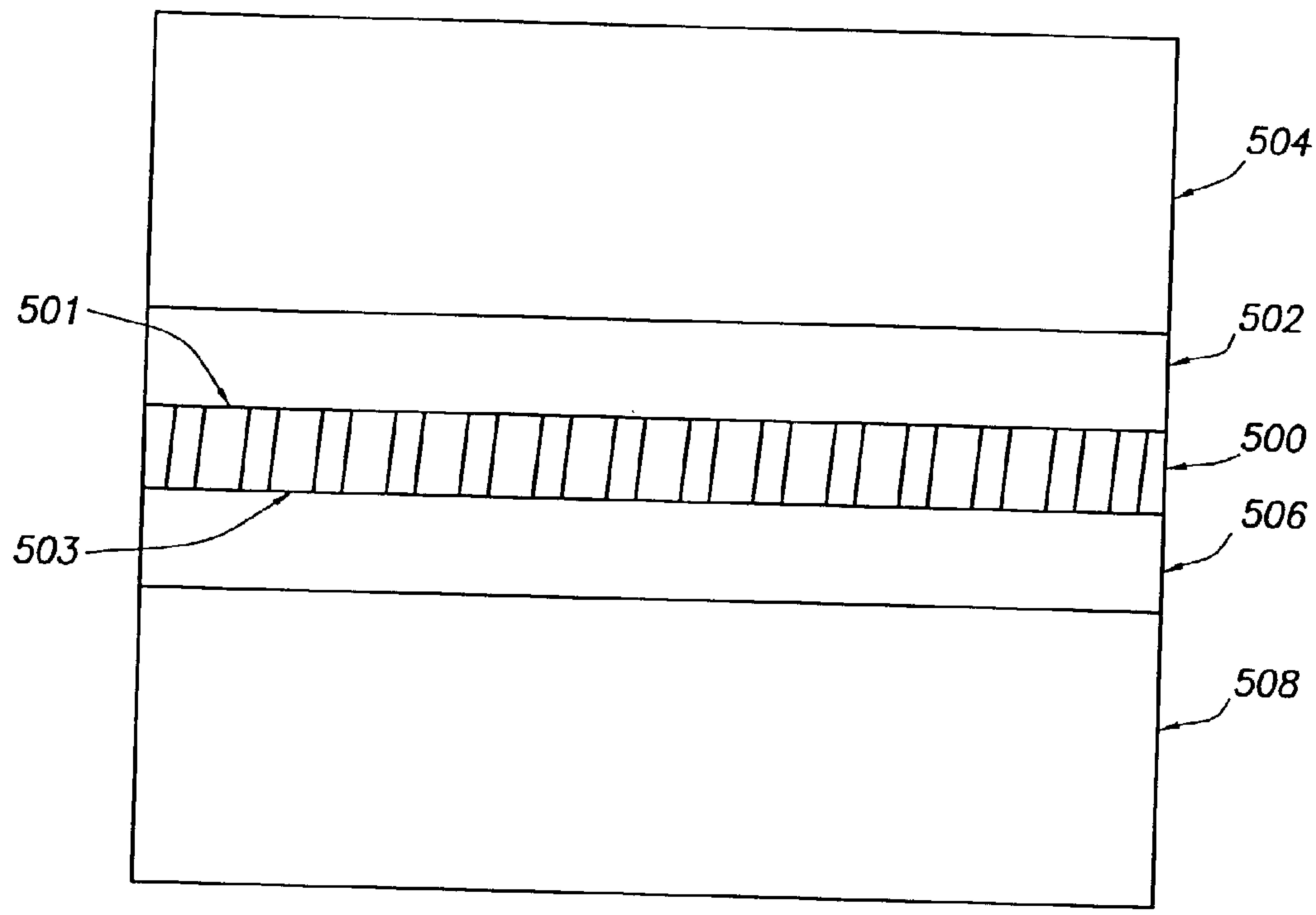


FIG. 1

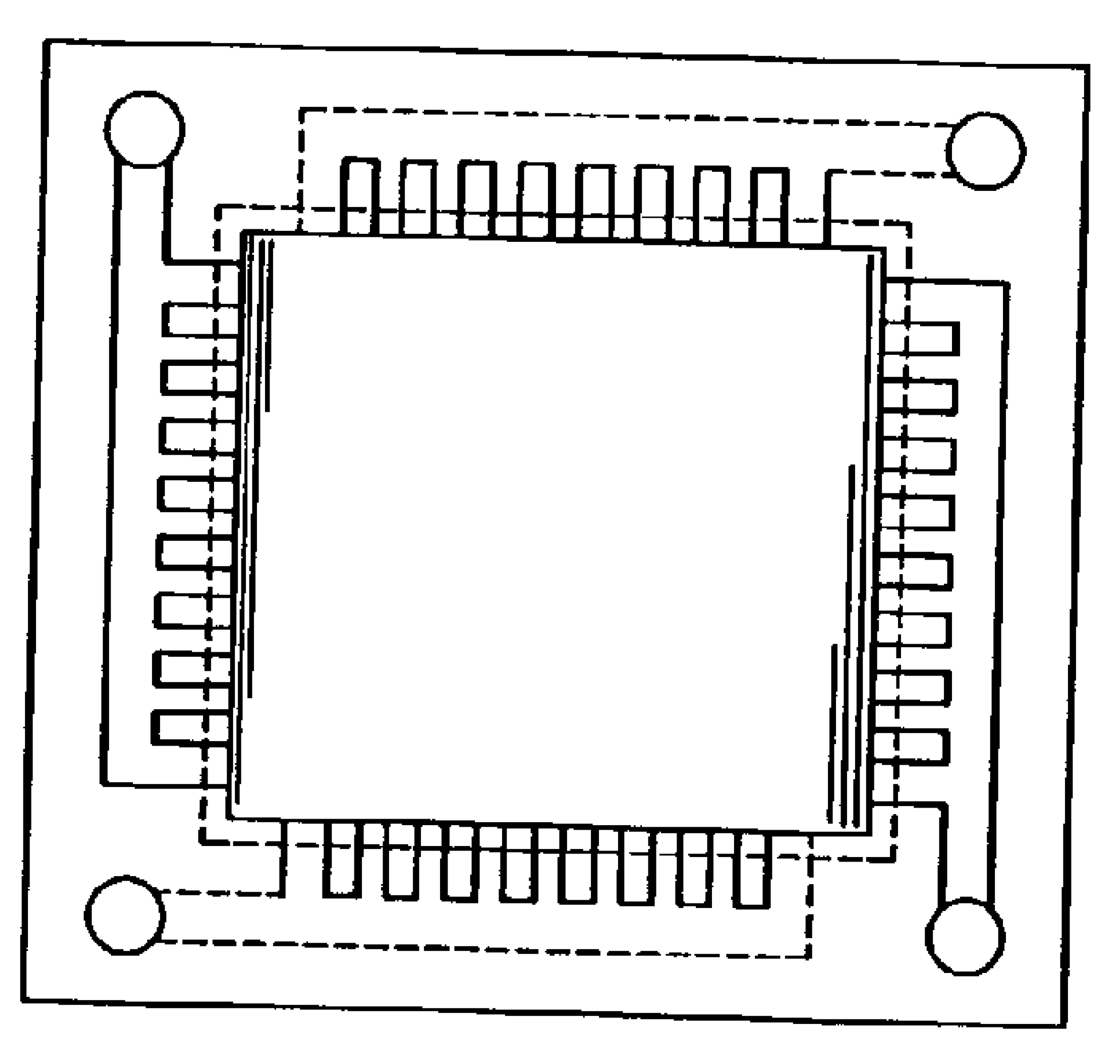
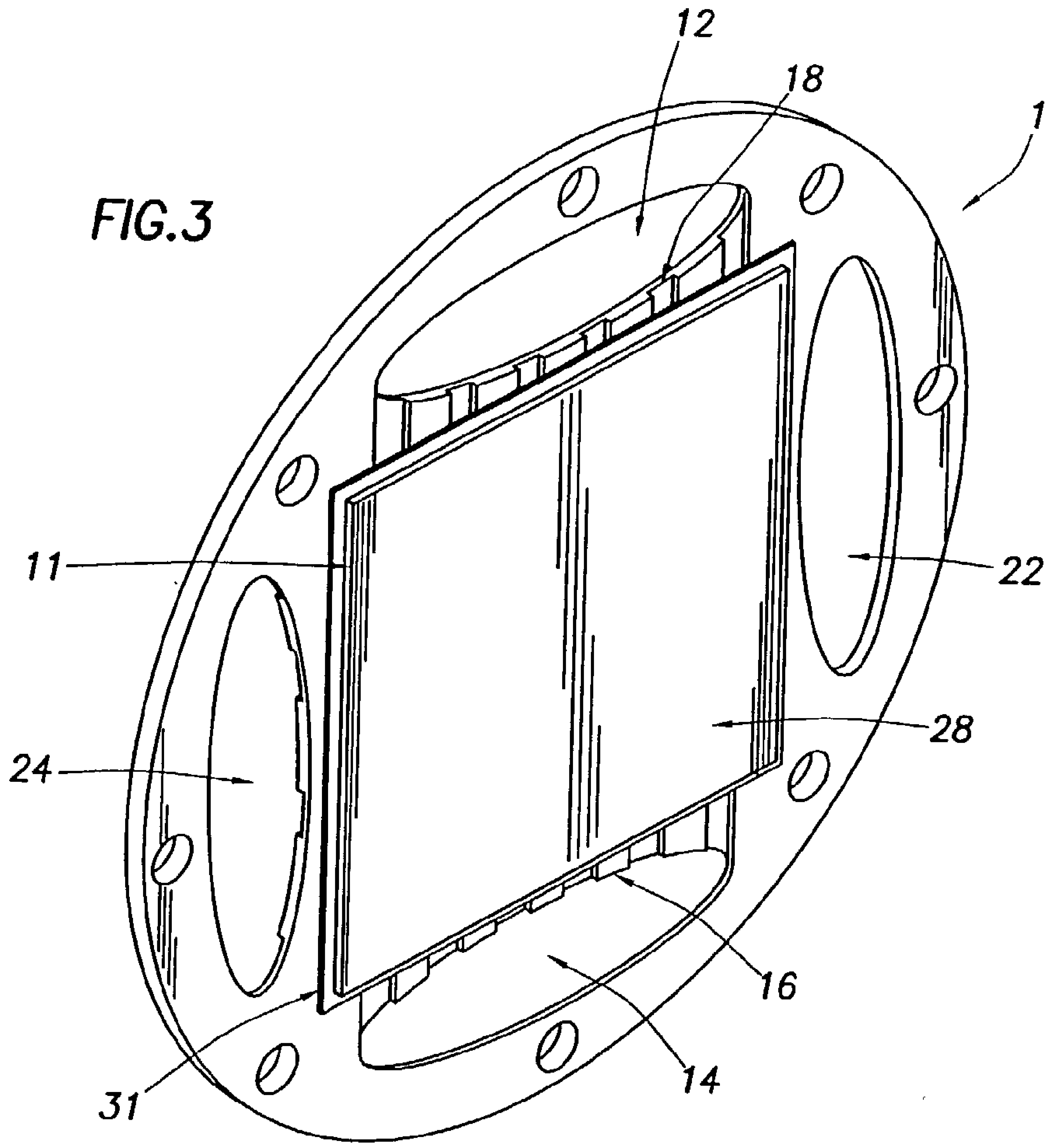


FIG. 2

FIG.3



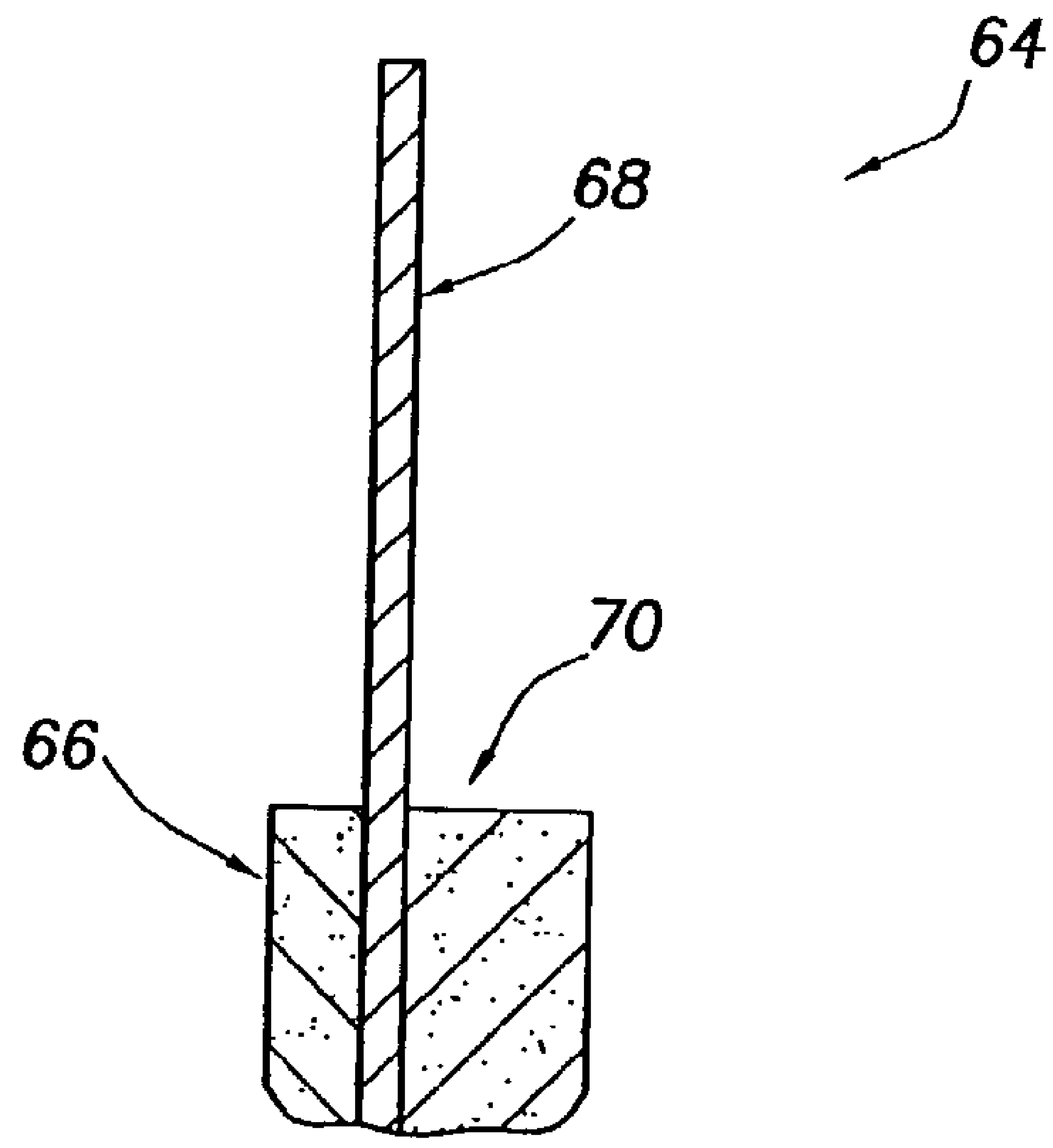


FIG.5

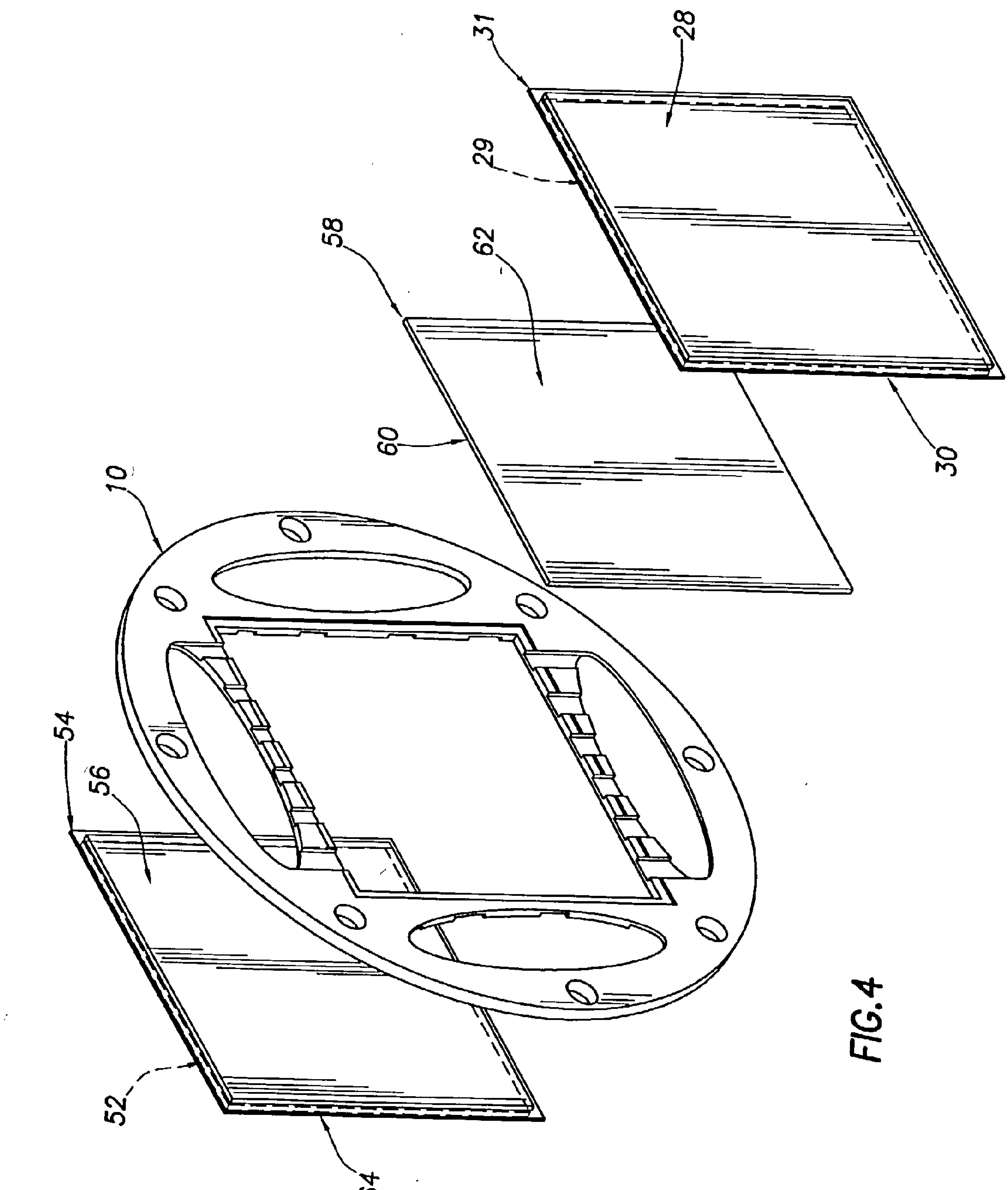


FIG.4

DISTRIBUTION FRAME FOR A FUEL CELL

RELATED REFERENCES

[0001] This application is a divisional of application Ser. No. 09/669,344, filed Sep. 26, 2000.

BACKGROUND OF THE INVENTION

[0002] The present invention relates in general to the field of proton exchange membrane ("PEM") fuel cell systems, and more particularly, to an improved PEM fuel cell system having improved discrete fuel cell modules with improved mass transport for ternary reaction optimization and a method for manufacturing same.

[0003] A fuel cell is an electrochemical device that converts fuel and oxidant into electricity and a reaction by-product through an electrolytic reaction that strips hydrogen molecules of their electrons and protons. Ultimately, the stripped electrons are collected into some form of usable electric current, by resistance or by some other suitable means. The protons react with oxygen to form water as a reaction by-product.

[0004] Natural gas is the primary fuel used as the source of hydrogen for a fuel cell. If natural gas is used, however, it must be reformed prior to entering the fuel cell. Pure hydrogen may also be used if stored correctly. The products of the electrochemical exchange in the fuel cell are DC electricity, liquid water, and heat. The overall PEM fuel cell reaction produces electrical energy equal to the sum of the separate half-cell reactions occurring in the fuel cell, less its internal and parasitic losses. Parasitic losses are those losses of energy that are attributable to any energy required to facilitate the ternary reactions in the fuel cell.

[0005] Although fuel cells have been used in a few applications, engineering solutions to successfully adapt fuel cell technology for use in electric utility systems have been elusive. The challenge is for the generation of power in the range of 1 to 100 kW that is affordable, reliable, and requires little maintenance. Fuel cells would be desirable in this application because they convert fuel directly to electricity at much higher efficiencies than internal combustion engines, thereby extracting more power from the same amount of fuel. This need has not been satisfied, however, because of the prohibitive expense associated with such fuel cell systems. For example, the initial selling price of the 200 kW PEM fuel cell was about $3500/kW to about $4500/kW. For a fuel cell to be useful in utility applications, the life of the fuel cell stack must be a minimum of five years and operations must be reliable and maintenance-free. Heretofore known fuel cell assemblies have not shown sufficient reliability and have disadvantageous maintenance issues. Despite the expense, reliability, and maintenance problems associated with heretofore known fuel cell systems, because of their environmental friendliness and operating efficiency, there remains a clear and present need for economical and efficient fuel cell technology for use in residential and light-commercial applications.

[0006] Fuel cells are usually classified according to the type of electrolyte used in the cell. There are four primary classes of fuel cells: (1) proton exchange membrane ("PEM") fuel cells, (2) phosphoric acid fuel cells, and (3) molten carbonate fuel cells. Another more recently developed type of fuel cell is a solid oxide fuel cell. PEM fuel cells, such as those in the present invention, are low-temperature low-pressure systems, and are, therefore, well-suited for residential and light-commercial applications. PEM fuel cells are also advantageous in these applications because there is no corrosive liquid in the fuel cell and, consequently, there are minimal corrosion problems.

[0007] Characteristically, a single PEM fuel cell consists of three major components—an anode gas dispersion field ("anode"); a membrane electrode assembly ("MEA"); and a cathode gas and liquid dispersion field ("cathode"). As shown in **FIG. 1**, the anode typically comprises an anode gas dispersion layer **502** and an anode gas flow field **504**; the cathode typically comprises a cathode gas and liquid dispersion layer **506** and a cathode gas and liquid flow field **508**. In a single cell, the anode and the cathode are electrically coupled to provide a path for conducting electrons between the electrodes through an external load. MEA **500** facilitates the flow of electrons and protons produced in the anode, and substantially isolates the fuel stream on the anode side of the membrane from the oxidant stream on the cathode side of the membrane. The ultimate purpose of these base components, namely the anode, the cathode, and MEA **500**, is to maintain proper ternary phase distribution in the fuel cell. Ternary phase distribution as used herein refers to the three simultaneous reactants in the fuel cell, namely hydrogen gas, water vapor and air. Heretofore known PEM fuel cells, however, for various reasons have not been able to efficiently maintain proper ternary phase distribution. Catalytic active layers **501** and **503** are located between the anode, the cathode and the electrolyte. The catalytic active layers **501** and **503** induce the desired electrochemical reactions in the fuel cell. Specifically, the catalytic active layer **501**, the anode catalytic active layer, rejects the electrons produced in the anode in the form of electric current. The oxidant from the air that moves through the cathode is reduced at the catalytic active layer **503**, referred to as the cathode catalytic active layer, so that it can oxidate the protons flowing from anode catalytic active layer **501** to form water as the reaction by-product. The protons produced by the anode are transported by the anode catalytic active layer **501** to the cathode through the electrolyte polymeric membrane.

[0008] In the typical PEM fuel cell assembly, a PEM fuel cell is housed within a frame that supplies the necessary fuel and oxidant to the anode and cathode flow fields of the fuel cell. These conventional frames typically comprise manifolds and channels that facilitate the flow of the reactants. However, usually the channels are not an integral part of the manifolds, which results in a pressure differential along the successive channels. **FIG. 2** is an illustration of a conventional frame for the communication of the reactants to a fuel cell. This pressure differential causes the reactants, especially the fuel, to be fed into the flow fields unevenly, which results in distortions in the flow fields causing hot spots and other problems leading to inefficiency. This also results in nonuniform disbursement of the reactants onto the catalytic active layers. Ultimately, this conventional method of supplying the necessary fuel and oxidant to a fuel cell results in a very inefficient process.

SUMMARY OF THE INVENTION

[0009] Accordingly, there is a need for an economical and efficient fuel cell assembly and fuel cell stack assembly that have an optimized supply and mass transport system. Herein provided is a an improved fuel/oxidant supply and distribution means. As a result of the present invention, significant improvement in, inter alia, power density, efficiency, and life of the fuel cell are provided at the cell and stack level.

[0010] In one embodiment, the distribution frame of the present invention comprises: a substantially planar frame, the substantially planar frame having an anode side, a cathode side, and a central cavity suitable for housing the fuel cell assembly; at least 2 fuel inlet apertures, the fuel inlet apertures extending completely through the distribution frame and each fuel inlet aperture being located 180° from the other, and each fuel inlet aperture having an interior side; an air inlet aperture, the air inlet aperture extending completely through the distribution frame and the air inlet aperture being located 90° from each fuel inlet aperture and 180° from an air and water outlet aperture, the air and water outlet aperture extending completely through the distribution frame, the air inlet aperture and the air and water outlet aperture each further having an interior side; a plurality of fuel supply channels, the fuel supply channels located on the anode side of the distribution frame and extending from the interior side of each fuel inlet aperture to the central cavity and being integral to each fuel inlet aperture; a plurality of air supply channels, the air supply channels located on the cathode side of the distribution frame and the air supply channels extending from the interior side of the air inlet aperture to the central cavity and being integral to the air inlet aperture; and a plurality of air and water outlet channels, the air and water outlet channels located on the cathode side of the distribution frame, the air and water outlet channels extending from the interior side of the air and water outlet aperture to the central cavity, and being integral to the air and water outlet aperture.

[0011] Other aspects and advantages of the present invention will be apparent to those ordinarily skilled in the art in view of the following specification claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] A more complete understanding of the present embodiments and advantages thereof may be acquired by referring to the following description taken in conjunction with the accompanying drawings, in which like numbers indicate like features, and wherein:

[0013] **FIG. 1** is a schematic of a typical PEM fuel cell assembly.

[0014] **FIG. 2** is an illustration of a conventional frame for housing and supplying reactants to a fuel cell assembly.

[0015] **FIG. 3** is a depiction of one embodiment of the distribution frame of the present invention housing a fuel cell assembly.

[0016] **FIG. 4** is an illustration of one embodiment of the fuel side of one embodiment of the distribution frame of the present invention.

[0017] **FIG. 5** is an illustration of one embodiment of the air side of one embodiment of the distribution frame of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0018] **FIG. 3** depicts one embodiment of an individual fuel cell assembly of the present invention. As shown in **FIG. 3**, fuel cell **11** is housed within distribution frame **10**. Distribution frame **10** not only houses fuel cell **1**, but also facilitates transportation of the fuel and the oxidant to the fuel cell necessary for the electrochemical exchange in the fuel cell. This individual fuel cell assembly can be combined with other fuel cell assemblies to form a fuel cell node, and ultimately a stack assembly, to provide higher voltages and current for power generation. Of note in **FIG. 3** are fuel inlet **22**, fuel inlet **24**, air inlet **12** and air and water outlet **14**. The fuel inlets **22** and **24**, air inlet **12**, and air and water outlet **14** are apertures in the distribution frame extending completely through the distribution frame, and run substantially perpendicular to, or at 90° angles from, one another in the distribution frame to facilitate the efficient flow of the fuel and oxidant to and through the anode gas and liquid flow field and cathode gas flow field, respectively.

[0019] Shown in **FIG. 4** is one embodiment of the anode side of distribution frame **10**. In this embodiment, fuel inlet **12** and fuel inlet **14** provide the fuel to the fuel cell housed within the cavity of distribution frame **10** necessary for the electrochemical reaction. Specifically, the fuel is fed to the anode gas flow field through fuel supply channels **18** and **16** that stretch from the interior sides or surfaces of fuel inlet **12** and fuel inlet **14**, respectively. Fuel supply channels **18** and **16** are shaped such that the supply of the fuel to the anode is preferably maintained at a constant velocity, i.e., the channels are of sufficient length, width and depth to provide fuel to the anode at a constant desired velocity. The velocity of the fuel entering the anode gas flow field via fuel supply channels **18** and **16** may be less than the velocity of oxidant entering the cathode gas flow field via air supply channels **25**. The number of fuel supply channels in the distribution frame stoichiometrically balances the number of air supply channels so as to achieve a 2.0 to 1.0 to 2.8 to 1.0, preferably 2.0 to 1.0 to 2.4 to 1.0, air to fuel ratio. Fuel supply channels **18** and **16** also provide an edge-on connection between the fuel supply inlets and the anode gas flow field of the fuel cell housed within the cavity of the distribution frame to allow for enhanced dispersion of the fuel through the anode gas flow field.

[0020] Suitable primary materials of construction for distribution frame **10** include, but are not limited to, nylon-6, 6, derivatives of nylon-6, 6, polyetheretherketone ("PEEK"), styrene, mylar, textar, kevlar or any other nonconductive thermoplastic resins such as polypropylene. Other materials may be suitable as recognized by those skilled in the art with the benefit of this disclosure. Materials that have good compression properties are most suitable; therefore, enhancements to improve their compression properties may be suitable. Distribution frame **10** is preferably substantially circular.

[0021] Shown in **FIG. 5** is the cathode side of distribution frame **10**. Air is a necessary reactant for the electrochemical exchange and may be fed to fuel cell **11** via air inlet **24** in combination with air supply channels **26**. Air supply channels **26** stretch from the interior surface or side of air inlet **24** to fuel cell **11**, and are of such sufficient size and shape that they enable air to be fed to the cathode gas flow field at a constant velocity, i.e., they are of sufficient height, width and depth. The number of fuel supply channels **18** and **16** will most often exceed the number of air supply channels **26** to maintain a stoichiometric balance of the reactants. Free water is formed continuously in the cathode gas and liquid flow field as a by-product of the electrochemical reaction. Air and water outlet **22** and air and water outlet channels **25** facilitate the flow of this free water from fuel cell **11** to allow for optimal water management in the fuel cell and to avoid flooding and the resultant loss in power. In a stack assembly, this free water may be transported for use in other parts of the fuel cell unit, unit here meaning the balance of plant assembly. Air and water outlet **22** and air and water outlet channels **25** also facilitate dissipation of the heat generated by the electrochemical reactions.

[**0022**] Although the present disclosure has been described in detail, it should be understood that various changes, substitutions, and alterations can be made hereto without departing from the spirit and the scope of the invention as defined-by the appended claims.

What is claimed:

1. A distribution frame for a fuel cell assembly comprising:

(a) a substantially planar frame, the substantially planar frame having an anode side, a cathode side, and a central cavity suitable for housing a fuel cell;

(b) at least 2 fuel inlet apertures, the fuel inlet apertures extending completely through the distribution frame and each fuel inlet aperture being located 180° from the other, and each fuel inlet aperture having an interior side;

(c) an air inlet aperture, the air inlet aperture extending completely through the distribution frame and the air inlet aperture being located 90° from each fuel inlet aperture and 180° from an air and water outlet aperture, the air and water outlet aperture extending completely through the distribution frame, the air inlet aperture and the air and water outlet aperture each further having an interior side;

(d) a plurality of fuel supply channels, the fuel supply channels located on the anode side of the distribution frame and extending from the interior side of each fuel inlet aperture to the central cavity and being integral to each fuel inlet aperture;

(e) a plurality of air supply channels, the air supply channels located on the cathode side of the distribution frame and the air supply channels extending from the interior side of the air inlet aperture to the central cavity and being integral to the air inlet aperture; and

(f) a plurality of air and water outlet channels, the air and water outlet channels located on the cathode side of the distribution frame, the air and water outlet channels extending from the interior side of the air and water outlet aperture to the central cavity, and being integral to the air and water outlet aperture.

2. The distribution frame for a fuel cell assembly according to claim 1 wherein the distribution frame is substantially circular.

3. The distribution frame for a fuel cell assembly according to claim 1 wherein the distribution frame is made from a nonconductive thermoplastic resin.

4. The distribution frame for a fuel cell assembly according to claim 1 wherein the distribution frame is made substantially from polypropylene.

5. The distribution frame for a fuel cell assembly according to claim 1 wherein the distribution frame is constructed from one or more of the following materials: nylon 6,6, derivatives of nylon 6,6, polyetheretherketone, styrene, mylar, textar, or kevlar.

6. The distribution frame for a fuel cell assembly according to claim 1 wherein the number of fuel supply channels balances the number of air supply channels so as to achieve an air to fuel stoichometric mixture of between 2.0 to 1.0 to 2.4 to 1.0.

7. The distribution frame for a fuel cell assembly according to claim 1 wherein the air inlet aperture has a rounded shape.

8. The distribution frame for a fuel cell assembly according to claim 1 wherein the fuel inlet apertures have a rounded shape.

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