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(56) Documents Cited
EP 1009051 A
US 6372376 B
US 6037073 A
WO 2000/031815 A
US 6171720 B
US 4649091 A

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(54) Abstract Title
Bipolar plates

(57) A bipolar plate for a fuel cell or electrolyser comprises a unitary body of electrically conductive material having on one face an oxidant flow field 7, on a reverse face a fuel flow field 8, and having an internal coolant flow field 6.

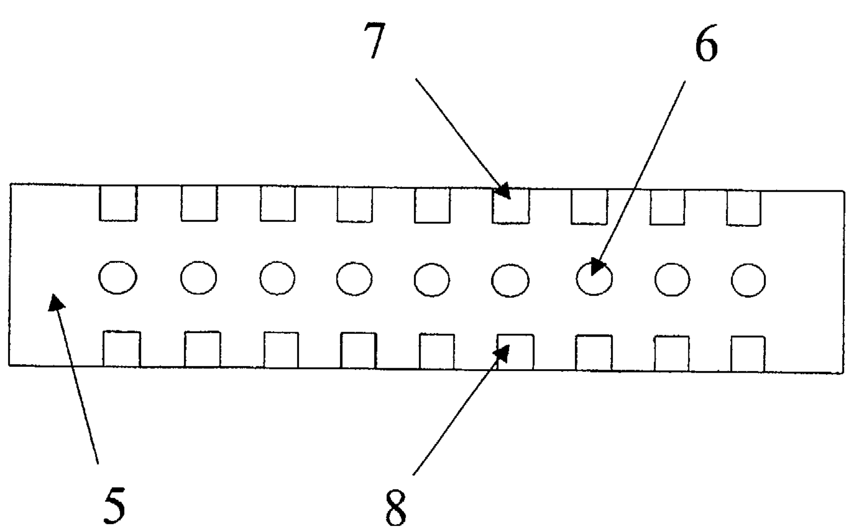

Fig. 2

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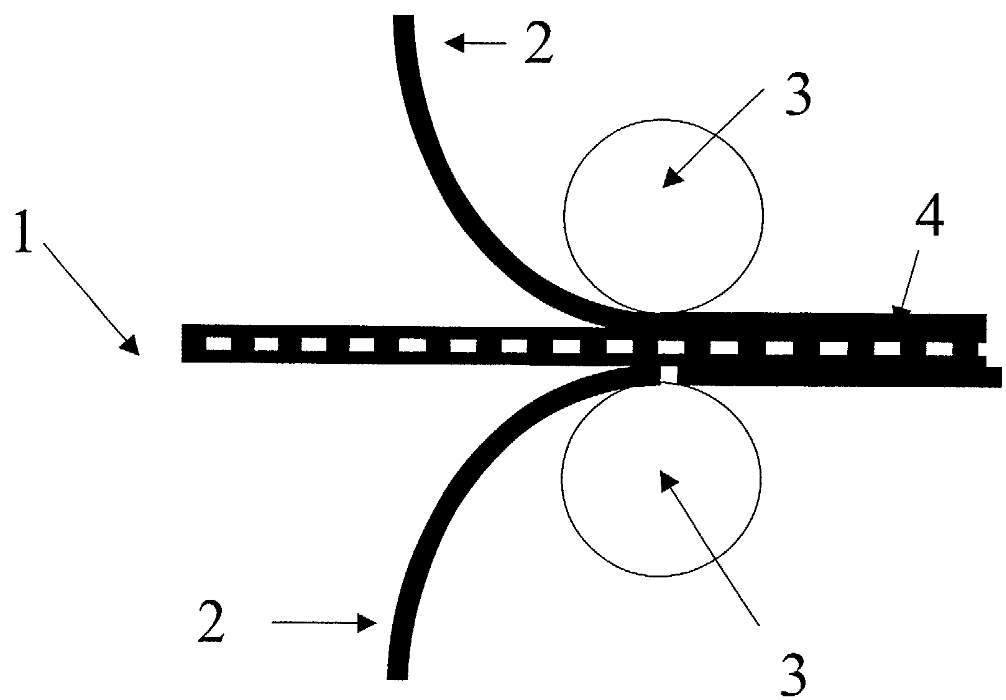

Fig. 1

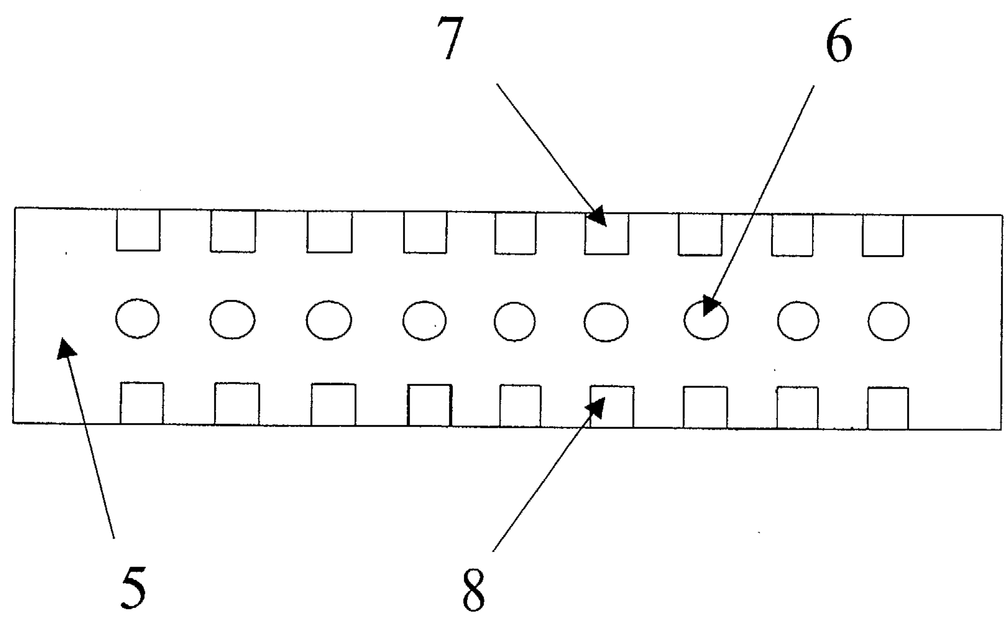

Fig. 2

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BIPOLAR PLATES

This invention relates to bipolar plates for fuel cells (for example polymer electrolyte fuel cells) and electrolysers. In the following, reference is made to fuel cells for the sake of convenience but the invention is equally applicable to electrolysers.

Fuel cells are devices in which a fuel and an oxidant combine in a controlled manner to produce electricity directly. By directly producing electricity without intermediate combustion and generation steps, the electrical efficiency of a fuel cell is higher than using the fuel in a traditional generator. This much is widely known. A fuel cell sounds simple and desirable but many man-years of work have been expended in recent years attempting to produce practical fuel cell systems.

One type of fuel cell in commercial production is the so-called proton exchange membrane (PEM) fuel cell [sometimes called polymer electrolyte or solid polymer fuel cells (PEFCs)]. Such cells use hydrogen as a fuel and comprise an electrically insulating (but ionically conducting) polymer membrane having porous electrodes disposed on both faces. The membrane is typically a fluorosulphonate polymer and the electrodes typically comprise a noble metal catalyst dispersed on a carbonaceous powder substrate. This assembly of electrodes and membrane is often referred to as the membrane electrode assembly (MEA).

Hydrogen fuel is supplied to one electrode (the anode) where it is oxidised to release electrons to the anode and hydrogen ions to the electrolyte. Oxidant (typically air or oxygen) is supplied to the other electrode (the cathode) where electrons from the cathode combine with the oxygen and the hydrogen ions to produce water. A sub-class of proton exchange membrane fuel cell is the direct methanol fuel cell in which methanol is supplied as the fuel. This invention is intended to cover such fuel cells and indeed any other fuel cell in which graphitic components are usable (e.g. alkaline fuel cells).

In commercial PEM fuel cells many such membranes are stacked together separated by flow field plates (also referred to as bipolar plates). The bipolar plates are typically formed of metal or graphite to permit good transfer of electrons between the anode of one membrane and the cathode of the adjacent membrane. The bipolar plates have a pattern of grooves on their surface to supply fluid (fuel or oxidant) and to remove water produced as a reaction product of the fuel cell.

To ensure that the fluids are dispersed evenly to their respective electrode surfaces a so-called gas diffusion layer (GDL) is placed between the electrode and the bipolar plate. The gas diffusion layer is a porous material and typically comprises a carbon paper or cloth, often having a bonded layer of carbon powder on one face and coated with a hydrophobic material to promote water rejection.

An assembled body of bipolar plates and membranes with associated fuel and oxidant supply manifolds is often referred to a fuel cell stack.

In operation fuel cell generate waste heat and so conventionally, at intervals along the stack, cooling sections are provided in which coolant flowing through a coolant flow field draws heat from the stack. The conductivity of the bipolar plates is relied upon to get heat from those membranes remote from the coolant section.

Such an arrangement has problems however since the efficiency of a stack is governed by the efficiency of the least efficient membrane electrode assembly in a stack (the same charge has to pass through each and every membrane electrode assembly in the stack). This means that:-

- If the cooling is not the same for each membrane it means that some membranes will be operating at different temperatures than other membranes, which means that they cannot all be operating at their most efficient.
- Membrane electrode assemblies remote from the coolant plate will lose most of their heat through the edge of the plate so leading to an uneven distribution of heat across the membrane electrode assembly. This leads to different efficiencies of operation across the membrane electrode assembly.

The inventors have realised that provision of a bipolar plate having an embedded coolant flow field offers significant advantages, in that coolant flow will be within each cell in a stack, and this offers a more uniform performance both within individual cells and between different cells in the stack.

Accordingly, the present invention provides a bipolar plate for a fuel cell or electrolyser, the bipolar plate comprising a unitary body of electrically conductive material having on one face an oxidant flow field, on a reverse face a fuel flow field, and having an internal coolant flow field. The invention also extends to fuel cells or electrolysers incorporating such bipolar plates.

Further features of the invention are set forth in the claims and the following description with reference to the drawings in which:-

Fig. 1 shows a method of forming a bipolar plate having buried coolant flow field;

Fig. 2 shows a bipolar plate having a buried coolant flow field..

Extrusion provides one route for the production of graphite plates having buried coolant flow fields. Extrusion should be taken to include visco-plastic processing. Visco-plastic processing is a process, used in the manufacture of ceramics, in which a particulate ceramic is mixed with a liquid medium to form a viscous composition which can be extruded, pressed, moulded or otherwise formed in like manner to rubbers and plastics.

In their co-pending patent application PCT/GB02/01977 the applicants have claimed methods of forming graphitic bodies comprising the steps of:-

a) forming under high shear a mouldable composition comprising:-

    i) graphite powder;

    ii) a binder; and

    iii) a fluid carrier

b) working said mouldable composition under high shear to form an extruded shape

c) forming bodies from said shape; and

d) heat treating said bodies to stabilise the structure.

These methods are incorporated herein as enabling the present invention, although it will be apparent to the skilled person from the following that other methods may be used.

Fig. 1 shows a preform 1 of a sacrificial material (explained below) and sheets 2 of a plastic composition being rolled together between pressing rollers 3 to produce a sheet 4 having an embedded preform. The plastic composition may be a graphitic material as described in PCT/GB02/01977 or an electrically conductive plastics material, or any other suitable material that results after treatment in an electrically conductive body for the bipolar plate.

Fig. 2 shows a bipolar plate 5 having an embedded coolant flow field 6 and with oxidant and fuel flow fields 7,8 on either side. The internal coolant flow field may be accessed either from the edge of the bipolar plate 5 or through one or both faces of the bipolar plate 5 as convenient.

The oxidant and fuel flow fields 7,8 may be formed by embossing. For example, the sheet 4 may pass between patterned rollers, which may emboss a grooved pattern into the surface of the shape. The pressing rollers 3 may fulfil this function. Alternatively, the oxidant and fuel flow fields may be formed by conventional machining or by the abrasive machining method of WO01/04982.

The preform of sacrificial material is removed during processing to leave a pattern of voids within the plate 5 forming the coolant flow field 6.

A variety of processes may be used including:-

1) **Using a high temperature cure (preferably single part) epoxy resin for the sacrificial material.**

The resin is first formed into the coolant flow field design at a temperature below curing using conventional injection moulding

The resin form is rolled between two sheets of plastic graphite material as described in PCT/GB02/01977.

The assembly of sheets and resin form is cured, during which process the resin melts and is wicked into the graphite material structure

If impregnation of the graphite material is required, the plate is further processed through resin impregnation. However, liquid resin is ejected from the water flow field by a compressed air blast prior to cure of the impregnant resin.

2) **Using wax for the sacrificial material.**

This will melt and evaporate during cure to leave the open flow field. (Analogous to the "lost wax" process used in metallurgy).

3) **Embossing prior to rolling**

For materials of appropriate rheology the coolant flow field may be em bossed on one or both sides of the two sheets of plastic graphite material to be rolled together. On rolling, the edges will be sealed but the flow field will remain open due to internal gas pressure. Further processing, if any, is as above.

Similar techniques may be adopted for use with other electrically conductive materials used in bipolar plate manufacture (e.g. electrically conductive polymers and polymer composites containing electrically conductive fillers). Alternative methods include die-pressing powders about a sacrificial preform. A common feature is the provision of a unitary body surrounding the coolant flow field.

By providing a unitary body, problems of sealing the coolant flow field are reduced and the thickness of the assembly of coolant flow field, oxidant flow field, and fuel flow field can be minimised. A bipolar plate of less than 5mm thickness, and even less than 2mm thickness, with an internal coolant flow field may be achieved.

A fuel cell or electrolyser comprising a plurality of such bipolar plates provides more uniform cooling and hence better performance.

CLAIMS

1. A bipolar plate for a fuel cell or electrolyser, the bipolar plate comprising a unitary body of electrically conductive material having on one face an oxidant flow field, on a reverse face a fuel flow field, and having an internal coolant flow field.

2. A fuel cell or electrolyser comprising a plurality of the bipolar plates of Claim 1.

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Claims searched:

Examiner: A.R.Martin
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Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): H1B

Int Cl (Ed.7): H01M 8/00

Other: On line databases WPI,EPODOC,JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	US 6037073 A	Lockheed se Fig 2	Claim 1 at least
X	US 6171720 B	UT-Batelle see Fig 2	"
X	US 6372376 B	General Motors see Fig 3	"
X	WO 00/31815 A	Inst.of Gas Technology see Fig 3	"
X	EP 1009051 A	General Motors see Fig 3	"
X	US 4649091 A	United Technologies see Fig 3	"

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.