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Novel Design of Fuel Cell Bipolar for Optimal Uniform Delivery of Reactant Gases and Efficient Water Removal

Susanta Das
sdas@kettering.edu

Jayesh Kavathe

Panini K. Kolavennu

Joel Berry
Kettering University, jberry@kettering.edu

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(54) **NOVEL DESIGN OF FUEL CELL BIPOLAR FOR OPTIMAL UNIFORM DELIVERY OF REACTANT GASES AND EFFICIENT WATER REMOVAL**

(76) Inventors: **Susanta K. Das**, Grand Blanc, MI (US); **Jayesh Kavathe**, Flint, MI (US); **Panini K. Kolavennu**, Hillsboro, OR (US); **K. Joel Berry**, Flint, MI (US)

Correspondence Address:
Jeremy J. Klobucar
Dickinson Wright PLLC
Ste. 2000, 38525 Woodward Ave.,
Bloomfield Hills, MI 48304-2970 (US)

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(57) **ABSTRACT**

The flow plate (**20**) defines stems (**76**), branches (**78**), and sub-branches (**80**) for moving fluid between each of the openings (**34**, **36**) and the active area (**42**). The openings (**34**, **36**) are trifurcated into two branches (**78**) and one stem (**76**) for providing flow of fluid through each of the stems (**76**) equal to the combined flow through co-diverging of the branches (**78**). The stems (**76**) have a minimal cross-sectional flow area less than the combined minimal cross-sectional flow area of the co-diverging of the branches (**78**). The stems (**76**) are bifurcated into two branches (**78**). The branches (**78**) have a uniform branch width (W_B) and are bifurcated into two sub-branches (**80**). The active area (**42**) includes manifolds (**46**, **48**) and active channels (**50**, **52**) extending therebetween. Each of the sub-branches (**80**) is in fluid communication with one of the manifolds (**46**, **48**). Each of the manifolds (**46**, **48**) is trifurcated into three active channels (**50**, **52**) for evenly distributing fluid between the openings (**34**, **36**) and the channels.

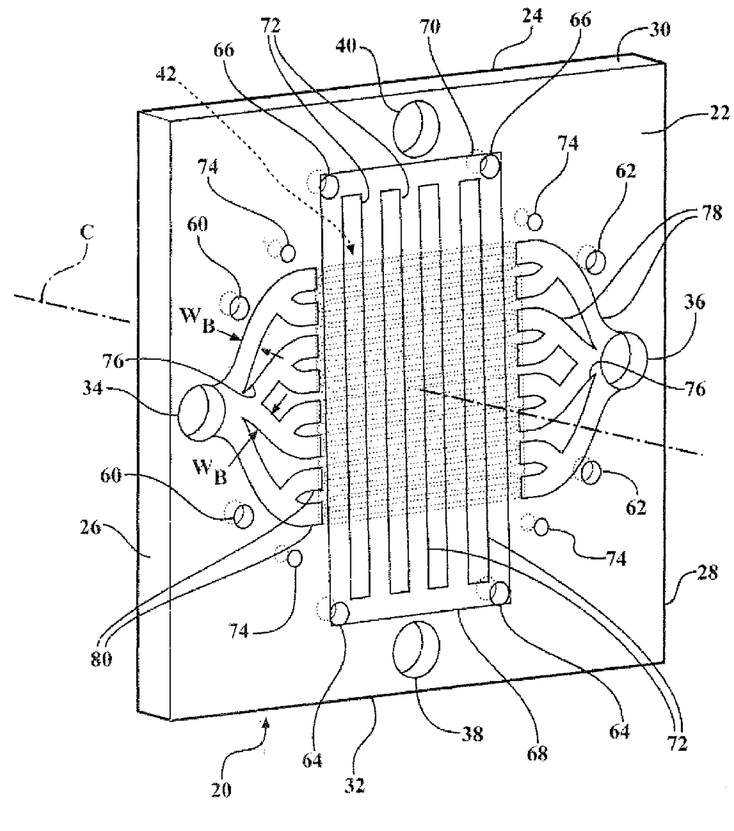


FIG. 1

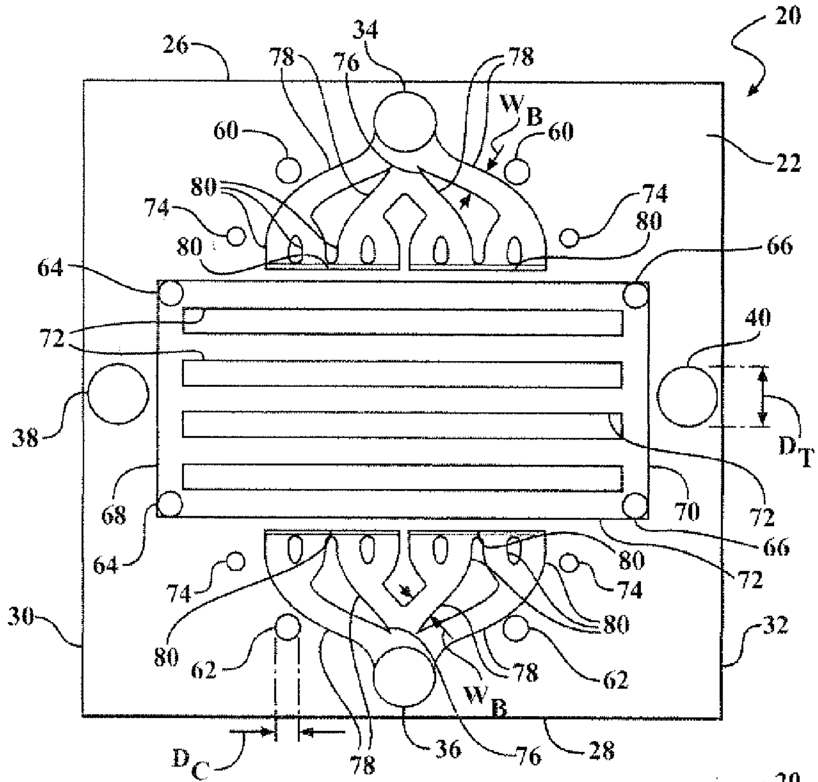
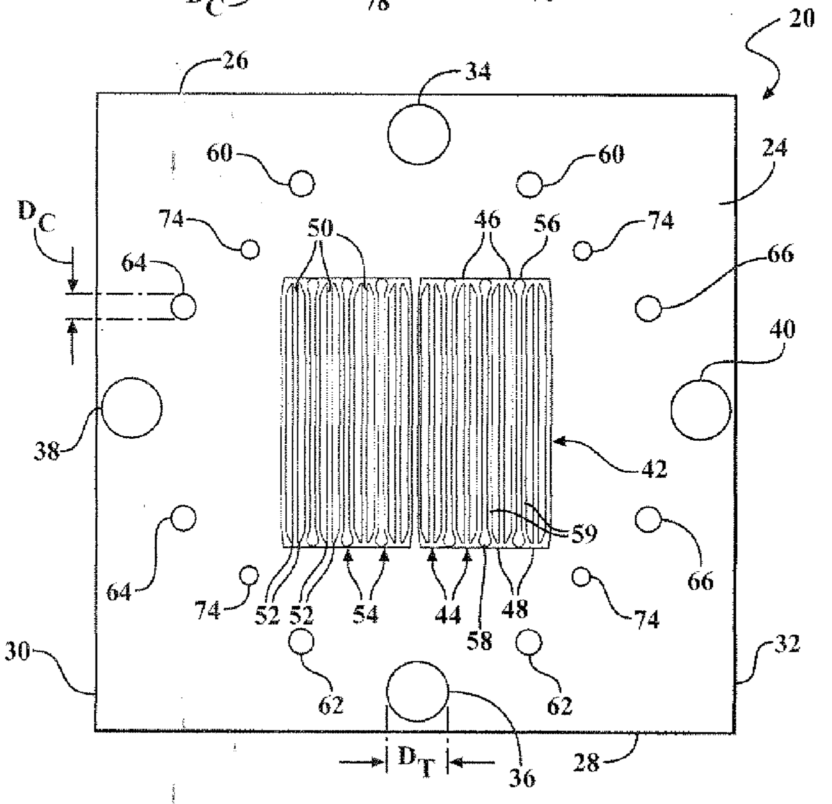

20
26
34
78
76
78
W_B
60
60
22
80
74
74
80
80
66
64
72
72
40
38
D_T
72
68
70
72
64
66
80
72
74
74
74
80
30
62
62
32
80
78
W_B
D_C
78
36
76
28

FIG. 2


20
26
34
60
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24
D_C
74
50
46
56
74
64
66
40
38
42
59
64
74
52
52
54
44
58
48
74
66
30
62
62
32
D_T
36
28

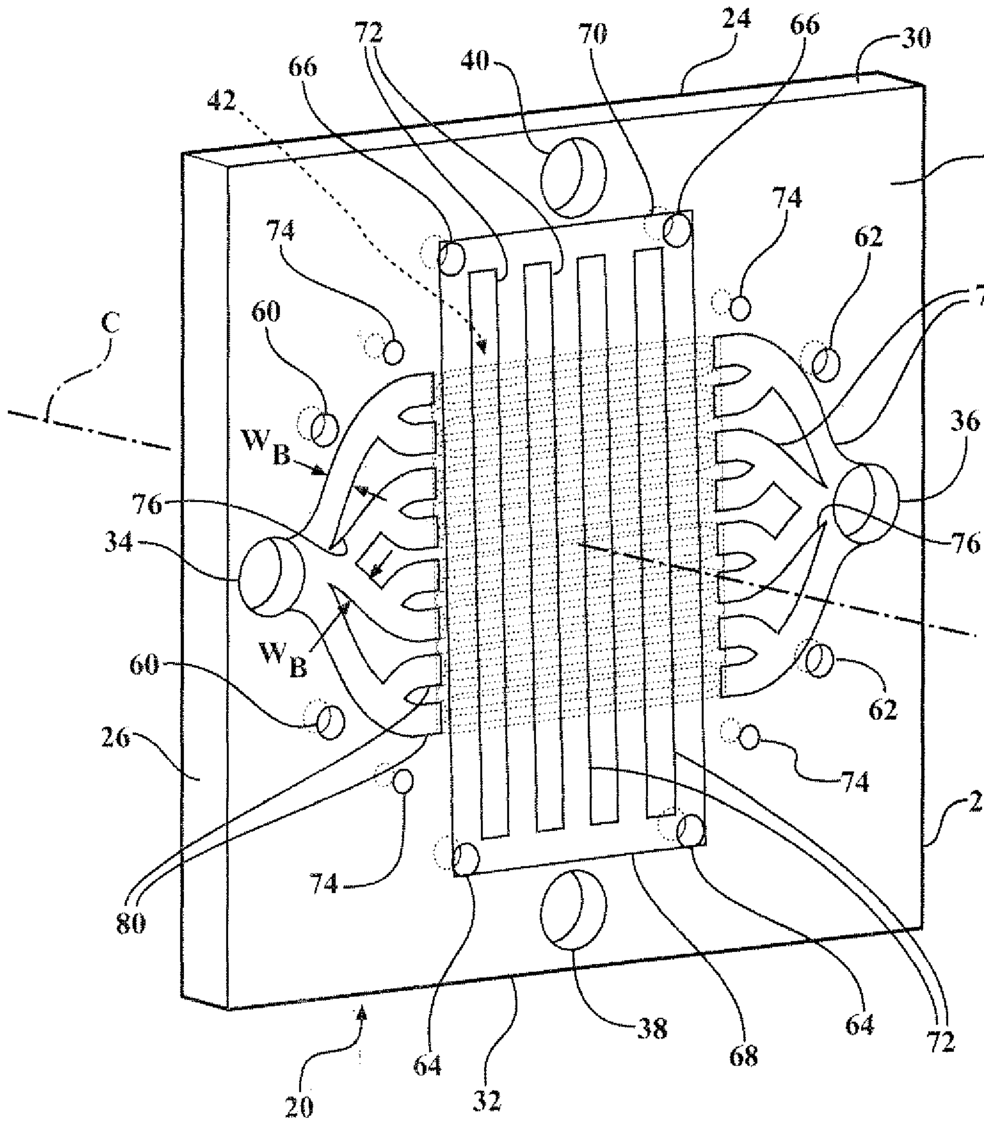
72
70
24
66
30
40
42
66
22
74
74
62
60
78
C
36
W_B
76
34
76
W_B
60
62
26
74
28
74
80
64
38
68
64
72
20
32

FIG. 3

NOVEL DESIGN OF FUEL CELL BIPOLAR FOR OPTIMAL UNIFORM DELIVERY OF REACTANT GASES AND EFFICIENT WATER REMOVAL

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of application Ser. No. 61/179,818 filed May 20, 2009.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] A flow plate for a fuel cell producing electrical current.

[0004] 2. Description of the Prior Art

[0005] Flow plates for a fuel cell producing electrical current are well known in the prior art. U.S. Pat. No. 7,018,733 to Seguira, for example, includes a flow plate defining a plurality of openings and an active area for presenting fluid for reaction. U.S. Pat. No. 7,067,213 to Boff includes branches for moving fluid between the openings and the active area.

SUMMARY OF THE INVENTION

[0006] At least one of said openings is trifurcated into two of the branches and one of the stems co-diverging therewith for providing flow of fluid through each of the stems equal to the combined flow through co-diverging of the branches.

ADVANTAGES OF THE INVENTION

[0007] The present invention increases the velocity and uniformity of fluid flow through the flow plate to improve reaction rates and remove water therefrom.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Other advantages of the present invention will be readily appreciated, as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0009] FIG. **1** is a front view of a flow plate according to the present invention;

[0010] FIG. **2** is a rear view of a flow plate according to the present invention; and

[0011] FIG. **3** is a perspective view of a flow plate according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0012] Referring to the Figures, wherein like numerals indicate corresponding parts throughout the several views, a fuel cell flow plate **20** defining a collector face **22** and a membrane face **24** parallel to the collector face **22**. The flow plate **20** has an inlet edge **26** and an outlet edge **28** parallel to the inlet edge **26**. The outlet edge **28** and the inlet edge **26** are interconnected by a first bypass edge **30** perpendicular to the inlet edge **26** and the outlet edge **28** and a second bypass edge **32** parallel to the first bypass edge **30** to define a square perimeter. The flow plate **20** defines a center axis C extending centrally therethrough and perpendicular to the membrane face **24** and the collector face **22**.

[0013] The flow plate **20** defines two openings **34**, **36** and two bypass holes **38**, **40** extending perpendicular to the membrane face **24** and the collector face **22**. Each of the openings **34**, **36** and the bypass holes **38**, **40** has a pass-through diameter D_T and the pass-through diameters D_T are equal. Each of the openings **34**, **36** and the bypass holes **38**, **40** are spaced inwardly from a different one of the edges **26**, **28**, **30**, **32** by an equal distance.

[0014] The openings **34**, **36** include an inlet opening **34** adjacent and inward from the inlet edge **26** and midway between the first bypass edge **30** and the second bypass edge **32**. The openings **34**, **36** include an outlet opening **36** radially opposite the inlet opening **34** and adjacent and inward from the outlet edge **28** and midway between the first bypass edge **30** and the second bypass edge **32**. The bypass holes **38**, **40** including a first bypass hole **38** adjacent and inward from the first bypass edge **30** and midway between the inlet edge **26** and the outlet edge **28** and disposed ninety degrees from the inlet opening **34** about the center axis C. The bypass holes **38**, **40** include a second bypass hole **40** radially opposite the first bypass hole **38** and adjacent and inward from the second bypass edge **32** and midway between the inlet edge **26** and the outlet edge **28**.

[0015] The membrane face **24** defines an active area **42** for presenting fluid for reaction. The active area **42** includes a plurality of channel sets **44** each including an inlet-side manifold **46** and an outlet-side manifold **48** and a plurality of the active channels **50**, **52** interconnecting the manifolds **46**, **48**. The membrane face **24** presents a plurality of ribs **54** each disposed between two adjacent of the channel sets **44** with each rib **54** defining an inlet head **56** and an outlet head **58** and each of the heads **56**, **58** being bulbous and interconnected by a straight section **59** parallel to the first bypass edge **30**.

[0016] The flow plate **20** defines a plurality of coolant holes **62**, **64**, **66**, **60** extending therethrough perpendicular to the membrane and collector faces **24**, **22**. The coolant holes **62**, **64**, **66**, **60** have coolant hole diameters D_C being equal. The coolant holes **62**, **64**, **66**, **60** include two inlet-side coolant holes **60** inward from and on either side of the inlet opening **34** and a pair of outlet-side coolant holes **62** inward from and on either side of the outlet opening **36**. The coolant holes **62**, **64**, **66**, **60** include two first bypass-side coolant holes **64** inward from and on either side of the first bypass hole **38** and two second bypass-side coolant holes **66** inward from and on either side of the second bypass hole **40**.

[0017] The collector face **22** defines a plurality of cooling channels **68**, **70**, **72** overlapping the active channels **50**, **52** of the membrane face **24**. The cooling channels **68**, **70**, **72** include a first bypass-side cooling channel **68** extending between the first bypass-side coolant holes **64** and parallel to the first bypass edge **30**. The cooling channels **68**, **70**, **72** including a second bypass-side cooling channel **70** extending between the second bypass-side coolant holes **66** and parallel to the first bypass-side cooling channel **68**. The cooling channels **68**, **70**, **72** include a plurality of transverse cooling channels **72** extending perpendicular to and between the first bypass-side cooling channel **68** and the second bypass-side cooling channel **70**.

[0018] The flow plate **20** defines a plurality of alignment holes **74** extending therethrough perpendicular to the collector and membrane faces **22**, **24**. One of the alignment holes **74** is between the inlet opening **34** and the second bypass hole **40**. One other of the alignment holes **74** is between the second bypass hole **40** and the outlet opening **36**. One other of the alignment holes **74** is between the outlet opening **36** and the first bypass hole **38**. One other of the alignment holes **74** is between the first bypass hole **38** and the inlet opening **34**,

[0019] The flow plate **20** is one of an anode flow plate **20** for presenting hydrogen for reaction and a cathode flow plate **20** for presenting oxygen for reaction.

[0020] The flow plate **20** defines a plurality of stems **76** and a plurality of branches **78** and a plurality of sub-branches **80** each extending arcuately and for moving fluid between each of said openings **34**, **36** and said active area **42**.

[0021] Each of the openings **34**, **36** is trifurcated into two of the branches **78** and one of the stems **76** co-diverging therewith and between the co-diverging of the branches **78** for providing flow of fluid through each of the stems **76** equal to the combined flow through of co-diverging of the branches **78**. Each of the stems **76** have a minimal cross-sectional flow area less than the combined minimal cross-sectional flow area of the co-diverging of the branches **78**. Each of the stems **76** is bifurcated into two of the branches **78**. Each of the branches **78** has a uniform branch width W_B and is bifurcated into two sub-branches **80**. Each of the sub-branches **80** is in fluid communication with one of the manifolds **46**, **48** of one of the channel sets **44**. Each of the manifolds **46**, **48** is trifurcated into three of the active channels **50**, **52** for evenly distributing fluid from the inlet into each of the active channels **50**, **52** with uniform velocity and pressure drop and for collecting fluid from each of the active channels **50**, **52** into the outlet opening **36** with uniform velocity and pressure drop.

[0022] The flow plate **20** defines a plurality of slots **82** each interconnecting adjacent of the sub-branches **80**. One of the slots **82** is adjacent each of the heads **56**, **58**. In an embodiment, the membrane face **24** defines the stems **76**, the branches **78**, and the sub-branches **80**. In another embodiment, the collector face **22** defines the stems **76**, the branches **78**, and the sub-branches **80**.

[0023] Each of the channel sets **44** including a middle active channel **50** extending perpendicular to the inlet edge **26** and a pair of diverging active channels **52** disposed adjacent the middle active channel **50** and diverging in opposite directions from the middle active channel **50** and the inlet-side manifold **46** and then extending parallel with the middle active channel **50** and converging into the outlet-side manifold **48** with the middle active channel **50**.

[0024] Obviously, many modifications and variations of the present invention are possible in light of the above teachings and may be practiced otherwise than as specifically described while within the scope of the appended claims. The use of the word "the" in the apparatus claims refers to an antecedent that is a positive recitation meant to be included in the coverage of the claims whereas the word "the" precedes a word not meant to be included in the coverage of the claims. In addition, the reference numerals in the claims are merely for convenience and are not to be read in any way as limiting.

What is claimed is:

1. A fuel cell flow plate (**20**) comprising:

said flow plate (**20**) defining a plurality of openings (**34**, **36**) and an active area (**42**) for presenting fluid for reaction and a plurality of branches (**78**) and a plurality of stems (**76**) for moving fluid between said openings (**34**, **36**) and said active area (**42**), and

at least one of said openings (**34**, **36**) being trifurcated into two of said branches (**78**) and one of said stems (**76**) co-diverging therewith for providing flow of fluid through each of said stems (**76**) equal to the combined flow through co-diverging of said branches (**78**).

2. A fuel cell flow plate (**20**) as set forth in claim **1** wherein each of said stems (**76**) has a minimal cross-sectional flow area less than the combined minimal cross-sectional flow area of co-diverging of said branches (**78**) more novelty details exist.

3. A fuel cell flow plate (**20**) as set forth in claim **1** wherein each of said sterns (**76**) are between co-diverging of said branches (**78**).

4. A fuel cell flow plate (**20**) as set forth in claim **1** wherein each of said stems (**76**) are bifurcated into two of said branches (**78**) for evenly moving fluid between trifurcated of said openings (**34**, **36**) and said branches (**78**) with uniform velocity and pressure drop.

5. A fuel cell flow plate (**20**) as set forth in claim **4** wherein each of said branches (**78**) have an equal branch width (W_B).

6. A fuel cell flow plate (**20**) as set forth in claim **4** wherein each of said branches (**78**) are bifurcated into two sub-branches (**80**) extending arcuately for evenly moving fluid between said branches (**78**) and said sub-branches (**80**) with uniform velocity and pressure drop.

7. A fuel cell flow plate (**20**) as set forth in claim **6** wherein said flow plate (**20**) defines a plurality of slots (**82**) each interconnecting adjacent of said sub-branches (**80**).

8. A fuel cell flow plate (**20**) as set forth in claim **6** wherein said active area (**42**) includes a plurality of channel sets (**44**) each including an inlet-side manifold (**46**) and an outlet-side manifold (**48**) and a plurality of said active channels (**50**, **52**) interconnecting said manifolds (**46**, **48**).

9. A fuel cell flow plate (**20**) as set forth in claim **8** wherein each of said sub-branches (**80**) are in fluid communication with one of said manifolds (**46**, **48**) of one of said channel sets (**44**).

10. A fuel cell flow plate (**20**) as set forth in claim **9** wherein each of said manifolds (**46**, **48**) are trifurcated into three of said active channels (**50**, **52**) for evenly moving fluid from between said sub-branches (**80**) and said active channels (**50**, **52**) with uniform velocity and pressure drop.

11. A fuel cell flow plate (**20**) as set forth in claim **10** wherein each of said channel sets (**44**) include a middle active channel (**50**) and a pair of diverging active channels (**52**) disposed adjacent said middle active channel (**50**) and diverging in opposite directions from said middle active channel (**50**) and said inlet-side manifold (**46**) and then extending parallel with said middle active channel (**50**) and converging into said outlet-side manifold (**48**) with said middle active channel (**50**).

12. A fuel cell flow plate (**20**) as set forth in claim **10** wherein said flow plate (**20**) defines a collector face (**22**) and a membrane face (**24**) parallel to said collector face (**22**) and has an inlet edge (**26**) and an outlet edge (**28**) parallel to said inlet edge (**26**) and interconnected by a first bypass edge (**30**) perpendicular to said inlet edge (**26**) and said outlet edge (**28**) and a second bypass edge (**32**) parallel to said first bypass edge (**30**) to define a square perimeter and said flow plate (**20**) defines a center axis (C) extending centrally therethrough and perpendicular to said membrane face (**24**) and said collector face (**22**).

13. A fuel cell flow plate (**20**) as set forth in claim **12** wherein said flow plate (**20**) defines two said openings (**34**, **36**) and two bypass holes (**38**, **40**) extending perpendicular to said membrane face (**24**) and said collector face (**22**) and each have pass-through diameters (D_T) being equal and each being radially spaced inwardly from a different one of said edges (**26**, **28**, **30**, **32**) by an equal distance and said openings (**34**, **36**) including an inlet opening (**34**) adjacent and inward from said inlet edge (**26**) and midway between said first bypass edge (**30**) and said second bypass edge (**32**) and said openings (**34**, **36**) including an outlet opening (**36**) radially opposite said inlet opening (**34**) and adjacent and inward from said outlet edge (**28**) and midway between said first bypass edge (**30**) and said second bypass edge (**32**) and said bypass holes (**38**, **40**) include a first bypass hole (**38**) adjacent and inward from said first bypass edge (**30**) and midway between said inlet edge (**26**) and said outlet edge (**28**) and disposed ninety degrees from said inlet opening (**34**) about said center axis (C) and said bypass holes (**38**, **40**) include a second bypass hole (**40**) radially opposite said first bypass hole (**38**) and adjacent and inward from said second bypass edge (**32**) and midway between said inlet edge (**26**) and said outlet edge (**28**).

14. A fuel cell flow plate (**20**) as set forth in claim **12** wherein said membrane face (**24**) defines said active channels (**50**, **52**) and said membrane face (**24**) presents a plurality of ribs (**54**) each disposed between two adjacent of said channel sets (**44**) with each rib (**54**) defining an inlet head (**56**) and an outlet head (**58**) and each of said heads (**56**, **58**) being bulbous and interconnected by a straight section parallel (**59**) to said first bypass edge (**30**) and one of said slots (**82**) being adjacent each of said heads (**56**, **58**).

15. A fuel cell flow plate (**20**) as set forth in claim **13** wherein said flow plate (**20**) defines a plurality of alignment holes (**74**) extending therethrough perpendicular to said collector and membrane faces (**22**, **24**) and one of said alignment holes (**74**) being between said inlet opening (**34**) and said second bypass hole (**40**) and one other of said alignment holes (**74**) being between said second bypass hole (**40**) and said outlet opening (**36**) and one other of said alignment holes (**74**) being between said outlet opening (**36**) and said first bypass hole (**38**) and a one other of said alignment holes (**74**) being between said first bypass hole (**38**) and said inlet opening (**34**).

16. A fuel cell flow plate (**20**) as set forth in claim **13** wherein said flow plate (**20**) defines a plurality of coolant holes (**62**, **64**, **66**, **60**) extending therethrough perpendicular to said membrane and collector faces (**24**, **22**) and having coolant hole diameters (D_C) being equal and said coolant holes (**62**, **64**, **66**, **60**) include two inlet-side coolant holes (**60**) inward from and on either side of said inlet opening (**34**) and a pair of outlet-side coolant holes (**62**) inward from and on either side of said outlet opening (**36**) and two first bypass-side coolant holes (**64**) inward from and on either side of said first bypass hole (**38**) and two second bypass-side coolant holes (**66**) inward from and on either side of said second bypass hole (**40**).

17. A fuel cell flow plate (**20**) as set forth in claim **16** wherein said collector face (**22**) defines a plurality of cooling channels (**68**, **70**, **72**) overlapping said active channels (**50**, **52**) of said membrane face (**24**) and said cooling channels (**68**, **70**, **72**) include a first bypass-side cooling channel (**68**) extending between said first bypass-side coolant holes (**64**) and parallel to said first bypass edge (**30**) and said cooling channels (**68**, **70**, **72**) include a second bypass-side cooling channel (**70**) extending between said second bypass-side coolant holes (**66**) and parallel to said first bypass-side cooling channel (**68**) and said cooling channels (**68**, **70**, **72**) include a plurality of transverse cooling channels (**72**) extending perpendicular to and between said first bypass-side cooling channel (**68**) and said second bypass-side cooling channel (**70**).

18. A fuel cell flow plate (**20**) as set forth in claim **12** wherein said collector face (**22**) defines said stems (**76**) and said branches (**78**) and said sub-branches (**80**).

19. A fuel cell flow plate (**20**) as set forth in claim **12** wherein said membrane face (**24**) defines said stems (**76**) and said branches (**78**) and said sub-branches (**80**).

20. A fuel cell flow plate (**20**) as set forth in claim **1** wherein said flow plate (**20**) is one of an anode flow plate (**20**) for presenting hydrogen for reaction and a cathode flow plate (**20**) for presenting oxygen for reaction.

21. A fuel cell flow plate (**20**) as set forth in claim **1** wherein said branches (**78**) and said stems (**76**) extend arcuately from said openings (**34**, **36**).

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