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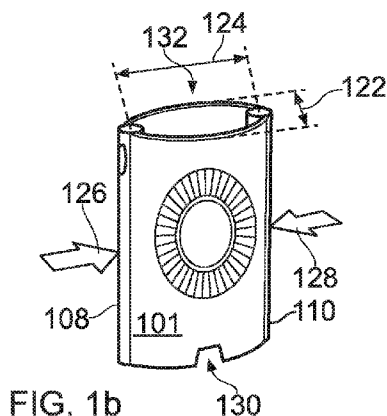
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(54) **Title:** FUEL CELL SYSTEM



(57) **Abstract:** The enclosure relates to a fuel cell system comprising: a housing having: a first, non- expanded configuration, and a second, expanded configuration for receiving a removable fuel cartridge within the housing; and a fuel cell for receiving fuel from the removable fuel cartridge.

Fuel Cell System

The present invention relates to a fuel cell system and, in particular, to a fuel cell system for receiving a removable fuel cartridge.

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Fuel cell systems, such as proton exchange membrane fuel cells (PEMFC), have been proposed as suitable energy sources for a wide range of applications including mobile devices and telecommunication or computing devices. However, a potentially undesirable attribute of some fuel-cell-powered devices is that the necessity to store fuel, or a fuel precursor, can substantially increase the bulk of the device, even when it is not in use. Conventional fuel cell systems also tend to be bulky due to the use of rigid fuel cells.

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Some attempts have been made to address these limitation by implementing a fuel cell system with a removable fuel cartridge. In such a fuel cell system the housing is adapted in order to accommodate the removable fuel cartridge within the housing. However, although the weight of such a system may be reduced when in storage by removal of the fuel cartridge, the volume occupied by the fuel cell system remains substantially the same whether or not the system is in use.

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According to a first aspect of the invention there is provided a fuel cell system comprising:
a housing having:

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a first, non-expanded configuration, and

a second, expanded configuration for receiving a removable fuel cartridge

within the housing; and

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a fuel cell for receiving fuel from the removable fuel cartridge.

By providing the housing with a first, non-expanded configuration and a second, expanded configuration the volume occupied by the fuel cell system when not in use may be reduced compared to prior art solutions.

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The fuel cell system may comprise an interface. The interface may be configured to engage with the fuel cartridge. The interface may be configured to deliver fluid from the fuel cartridge to the fuel cell. The interface may be pivotably connected to the first part. The interface may have a first, aligned configuration in which the interface is engaged with the first part. The interface may have a second, expanded configuration for receiving a fluid from the fuel cartridge.

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The fuel cell may be integrally formed with the housing. The fuel cell may be flexible. The fuel cell may have an anode face and a cathode face. The anode face may be disposed within the housing. The cathode face may be disposed on an external surface of the housing.

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The housing may comprise a first part and a second part. The first part may be disposed a first distance from the second part in the first configuration of the housing. The first part may be disposed a second distance from the second part in the second configuration of the housing. The second distance may be greater than the first distance. The first part may comprise a first fuel cell. The second part may comprise a second fuel cell.

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The first part may have a first edge and an opposing second edge. The second part may have a first edge and an opposing second edge. The first edge of the first part may be connected to the first edge of the second part. The second edge of the first part may be connected to the second edge of the second part. The first edge may be a greater distance from the second edge in the first configuration than in the second configuration. The housing may comprise at least one connecting member that connects the first part to the second part. The at least one connecting member may comprise a first connecting member that extends along the first edges of the first and second parts. The at least one connecting member may comprise a second connecting member that extends along the second edges of the first and second parts. Each connecting member may be pivotably connected to the first and second parts. The at least one connecting member may be pivotably connected to the first and second parts. The at least one connecting member may comprise a recess for an electrical cable for providing power from the fuel cell.

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The housing, in the second, expanded configuration, may form an open cavity for receiving the removable fuel cartridge.

According to a further aspect there is provided a mobile telecommunication or computing device comprising the fuel cell system.

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According to a further aspect there is provided a charging apparatus for a mobile telecommunication or computing device, the charging apparatus comprising the fuel cell system.

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According to a further aspect there is provided a fuel cartridge for the fuel cell system.

Embodiments of the invention will now be described by way of example and with reference to the accompanying drawings in which:

figure 1a illustrates a fuel cell system with a housing in a first, non-expanded configuration;

5 figures 1b to 1d illustrate the fuel cell system of figure 1a in which the housing is in a second, expanded configuration;

figure 2a illustrates another fuel cell system with a housing in a first, non-expanded configuration; and

10 figures 2b and 2c illustrate the fuel cell system of figure 2a in which the housing is in a second, expanded configuration.

The disclosure relates to a fuel cell system comprising a housing and a fuel cell. The fuel cell may be integrally formed with the housing or mounted on the housing. The housing has a first, non-expanded configuration, and a second, expanded configuration. The first
15 non-expanded configuration can enable the housing to have a low cross section profile when the fuel cell system is not in use. In some examples, the housing may have substantially no internal volume in the first non-expanded configuration. Whereas, in the second, expanded configuration, the housing can form an open-ended cavity, or capture volume, for receiving a removable fuel cartridge within the housing. The open cavity in the
20 second configuration may have a substantial volume in comparison with the first configuration. In this way, the bulk of the fuel cell system may be reduced when not in use compared to systems in which a fixed volume cavity is provided for receiving a removable fuel cartridge.

25 The fuel supplied to the fuel cell by the cartridge may be hydrogen gas. The removable fuel cartridge may be provided by a hydrogen storage device or a hydrogen generating cartridge, for example. An example of hydrogen gas generating cartridge that may be used with some examples of the housing disclosed herein is provided by granted United States Patent US8764858 (B2) (which corresponds to US application number 13/021798),
30 which is incorporated herein by reference.

The fuel cell may be a proton exchange membrane fuel cell, for example. One or more fuel cells may be provided on all surfaces of the housing, or even on a full 360° of a surface of the housing. Alternatively, the fuel cell may form only a portion, such as a half of the
35 housing, with the remaining portion of the housing just providing mechanical support for the cartridge. The fuel cell typically has an anode face and a cathode face. The anode face may be disposed within the housing for receiving fuel from the fuel cartridge. In some

examples, the anode face of a fuel cell may receive fuel directly from an adjacent face of the fuel cartridge. The cathode face may be disposed on an external surface of the housing for breathing ambient air. The fuel cell may be a single fuel cell or a plurality of fuel cells. The plurality of fuel cells may be arranged in a stack.

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The housing may comprise a plastics material. In some examples, the housing may be flexible but the fuel cells are rigid. Alternatively, the fuel cell itself may be flexible.

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A flexible item, such as a part of the housing or a fuel cell, may be reversibly deformable such that a tangent at a first edge of the fuel cell forms an angle of 10 degrees or 30 degrees, for example, with respect to a tangent at a second edge of the fuel cell. A rigid item may only be reversibly deformable such that a tangent at a first edge of the fuel cell forms an angle of less than 10 degrees or 30 degrees, for example.

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Figures 1a to 1d illustrate a fuel cell system 100 comprising a housing 101 with a first, non-expanded configuration, illustrated in figure 1a, and a second, expanded configuration, illustrated in figures 1b to 1d. A Fuel cartridge 102 is also shown in conjunction with the fuel cell system 100 in figures 1c and 1d.

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The housing 101 of the fuel cell system 100 provides an external housing 101 for a charging apparatus in this example. The housing 101 comprises a first part 104 and a second part 106. The first part 104 and the second part 106 each provide a flexible wall with an integrally formed fuel cell. In this way, the first part 104 comprises a first integrally formed fuel cell and the second part comprises a second integrally formed fuel cell.

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The housing 101 has a first edge 108 and an opposing second edge 110. Each of the first part 104 and the second part 106 has a first edge at the first edge 108 of the housing 101. Each of the first part 104 and the second part 106 has a second edge at the second edge 110 of the housing 101. The first edge of the first part 104 is connected to the first edge of the second part 106 by a first connecting member 112. The first connecting member 112 extends along the first edges of the first and second parts 104, 106 and connects the first part 104 to the second part 106 at the first edge 108 of the housing 101. The second edge of the first part 104 is connected to the second edge of the second part 106 by a second connecting member 114. The second connecting member 114 extends along the second edges of the first and second parts 104, 106 and connects the first part 104 to the second part 106 at the second edge 110 of the housing 101.

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The fuel cell system 100 also comprising an interface 116 configured to engage with the fuel cartridge 102 and deliver fluid from the fuel cartridge 102 to the fuel cells in the housing 101. The interface 116 may be considered to be a type of connector. In this example, the interface is mounted on the first part 104 and extends from the first part 104 towards the second part 106.

The first and second parts 106, 108 are each biased such that, absent the application of an external force, the first and second parts 106, 108 each adopt a planar configuration. The planar configuration of the first and second parts 106, 108 of the fuel cell system 100 is an example non-expanded configuration.

In Figure 1a, the fuel cell system 100 is illustrated with its housing 101 in the first, non-expanded configuration. In the first, non-expanded configuration, a central portion of the first part 104 is disposed a first distance 118 from a central portion of the second part 106. In the first, non-expanded configuration, a first width 120 is provided between the first edge 108 of the housing 101 and the second edge 110 of the house 100. In the first configuration, the housing occupies a relatively small volume because the first part 104 is provided adjacent to the second part 106.

The fuel cell system 100 can be transitioned from the first, non-expanded configuration to the second, expanded configuration by an application of external biasing forces 126, 128 (illustrated in figure 1b) inwardly on the opposing edges 108, 110 of the housing 101 in order to urge the first edge and second edges 108, 110 towards each other and overcome the bias of the first and second parts 106, 108 toward to planar configuration.

In Figure 1b to 1d the fuel cell system 100 is illustrated with its housing 101 in the second, expanded configuration. In the second, expanded configuration, the central portion of the first part 104 is disposed a second distance 122 from the central portion of the second part 106. The second distance 122 of the second configuration is greater than the first distance 118 of the first configuration. A second width 124 is provided between the first edge 108 of the housing 101 and the second edge 110 of the house 100. The second width 124 of the second configuration is greater than the first width 120 of the first configuration. As such, the housing 101 forms an open-ended cavity, or capture volume, for receiving the removable fuel cartridge 102 within the housing 101 when in the second configuration.

In figure 1c, the removable fuel cartridge 102 is shown partially inserted into the open-ended cavity formed by the housing 101 in the second, expanded configuration.

Application of a force 129 on the removable fuel cartridge 102 can urge the fuel cartridge 102 into the housing 101 and removably engage the removable fuel cartridge 102 with the interface 116 (illustrated in figure 1a not visible in figure 1c). The interface 116 may be configured to retain the fuel cartridge 102 within the housing 101 using a friction fit, for example, with a corresponding interface (not shown) on the removable fuel cartridge 102.

Once the removable fuel cartridge 102 has been partially inserted into the open-ended cavity, the external biasing forces 126, 128 may be removed because bias of the first and second parts 104, 108 towards the planar configuration causes the housing 101 to be clasped against the cartridge 102 maintains the shape of the open-ended cavity.

In figure 1d, the removable fuel cartridge 102 is fully inserted into the open-ended cavity formed by the housing 101 in the second, expanded configuration. In this example, the fuel cartridge 102 does not extend beyond the housing 101 at the open end 132.

The second part 106 has an indentation 130 that is best seen in figures 1b to 1d. The indentation 130 is provided for the interface 116 to extend through when the housing 101 is in the first, non-expanded configuration. The indentation 130 therefore ensures that the interface 116 does not interfere with the second part 106 when the housing 101 is in the first, non-expanded configuration. The indentation 130 may also assist a user in ejecting the removable fuel cartridge 102 from the housing 101 because the indentation 130 provides a finger hole that may be used to push the removable fuel cartridge 102 back out of the open end 132 of the housing 101.

Once the removable fuel cartridge 102 has been removed from the open-ended cavity, the biasing of the first and second parts 104, 106 towards the planar configuration causes the housing 101 to transform from the second, expanded configuration back to the first, non-expanded configuration.

As shown in figure 1d, the second connecting member 114 in this example comprises a recess for an electrical cable 134. The cable has a connector 136 for connecting the fuel cells in the housing 101 to a device (not shown) in order to provide power from the fuel cell to the device. The connector 136 may be a standard connector, such as a USB connector, or a proprietary connector. The provision of a proprietary connector may be advantageous for implementations in which the fuel cells are not rated to provide power at a particular level as required by standards such as USB.

Figures 2a to 2c illustrate another fuel cell system 200 comprising a housing 201 with a first, non-expanded configuration, and a second, expanded configuration for receiving a removable fuel cartridge within the housing 201. In this example, the fuel cell system 200 is integrally formed with an external housing 201 of a mobile telephone, which is an example of a mobile telecommunications device and a computing device.

As in the example described with reference to figure 1 above, the fuel cell system 200 has a housing 201 comprising a first part 204 and a second part 206. The first part 204 is provided by a body of the mobile telephone handset and the second part 206 is a back cover that can be displaced with respect to the first part 204. In this example, a fuel cell is provided within the body of the handset. The second part 206 provides a bracket to mechanically support the cartridge 202. It will be appreciated that the fuel cell could also be provided in the second part 206.

The housing 201 has a first edge 208 and an opposing second edge 210. The second part 206 has a first edge at the first edge 208 of the housing 201 and a second edge at the second edge 210 of the housing 201.

The first part 204 is connected to the first edge of the second part 206 by a first set of connecting members 212a, 212b. The first part 204 is connected to the second edge of the second part 206 by a second set of connecting members (not shown).

Each of the connecting member of the first and second sets of connecting members 212a, 212b is pivotably connected to both the first part 204 and the second part 206. The connecting members 212a, 212b are biased such that, absent the application of an external force, the second part 206 is clasped against the first part 204 in a non-expanded configuration.

Figure 2a illustrates the housing 201 in the first, non-expanded configuration. In the first, non-expanded configuration of the housing 201, the first part 204 is disposed a first distance 218 from the second part 206. In this example, there is substantially no volume within the housing between the first part 204 and the second part 206 in the first configuration.

The fuel cell system 200 also comprising an interface 216 pivotably connected to the first part 204. In the first, non-expanded configuration of the housing 101, the interface 216 has a first, aligned configuration in which the interface is engaged with the first part 204.

Figure 2b and 2c illustrate the fuel cell system of figure 2a in which the housing 201 is in a second, expanded configuration. In the second configuration of the housing 201, the first part 204 is disposed a second distance 222 from the second part 206. The second
5 distance 222 in the second configuration is greater than the first distance 218 in the first configuration.

As shown in figure 2b, the housing forms an open-ended cavity between the first and second parts 204, 206 in the second configuration. A removable fuel cartridge 202 can be
10 slidably engaged with the open-ended cavity defined by the first and second parts 204, 206.

Also as shown in figure 2b, the interface 216 has a second, expanded configuration for engaging with, and retaining in place, the fuel cartridge 202 and delivering fluid from the
15 fuel cartridge 202 to the fuel cells in the housing 201. The distribution of fuel from the interface 216 to an anode of the fuel cell may be achieved using a fluid distribution gallery. The interface 216 may be pivoted from the first, aligned configuration to the second, expanded configuration when the housing transitions from the first configuration to the second configuration. The pivoting of the interface 216 with respect to the first part 204 of
20 the housing may be mechanically linked to the pivoting of the connecting members 212a, 212b with respect to the first part 204 of the housing.

An anode face of the fuel cell is shown integrated with the first part 204 of the housing 201. The anode face of the fuel cell faces the cavity formed between the first and second parts
25 204, 206. In some examples, such an open anode face may interface directly with the fuel cartridge 202 and so a separate interface 216 may not be necessary, or may only retain the removable fuel cartridge in place rather than deliver fuel.

In figure 2c, the removable fuel cartridge 202 is illustrated within the cavity defined by the
30 housing 201 in the second configuration. The removable fuel cartridge 202 is braced by the first and second parts 204, 206 and engaged with the interface 216. In this way, the removable fuel cartridge 202 may be held securely by the housing 201.

Claims

1. A fuel cell system comprising:
a housing having:
5 a first, non-expanded configuration, and
a second, expanded configuration for receiving a removable fuel cartridge
within the housing; and
a fuel cell for receiving fuel from the removable fuel cartridge.
- 10 2. The fuel cell system of claim 1 in which the fuel cell is integrally formed with the housing.
3. The fuel cell system of claim 1 or claim 2 comprising an interface configured to engage with the fuel cartridge and deliver fluid from the fuel cartridge to the fuel cell.
- 15 4. The fuel cell system of claim 3 in which the interface is pivotably connected to the first part and has:
a first, aligned configuration in which the interface is engaged with the first part;
and
20 a second, expanded configuration for receiving a fluid from the fuel cartridge.
5. The fuel cell system of any preceding claim in which the fuel cell is flexible.
6. The fuel cell system of any preceding claim in which:
25 the fuel cell has an anode face and a cathode face;
the anode face is disposed within the housing; and
the cathode face is disposed on an external surface of the housing.
7. The fuel cell system of any preceding claim in which:
30 the housing comprises a first part and a second part;
the first part is disposed a first distance from the second part in the first configuration of the housing; and
the first part is disposed a second distance from the second part in the second configuration of the housing, the second distance being greater than the first distance.
- 35 8. The fuel cell system of claim 7 in which:
the first part comprises a first fuel cell; and

the second part comprises a second fuel cell.

9. The fuel cell system of claim 7 or claim 8 in which:

the first part has a first edge and an opposing second edge;

5 the second part has a first edge and an opposing second edge;

the first edge of the first part is connected to the first edge of the second part; and

the second edge of the first part is connected to the second edge of the second

part.

10 10. The fuel cell system of claim 9 in which the first edge is a greater distance from the second edge in the first configuration than in the second configuration.

11. The fuel cell system of any of claims 7 to 10 in which the housing comprises at least one connecting member that connects the first part to the second part.

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12. The fuel cell system of claim 11 in which the at least one connecting member comprises:

a first connecting member that extends along the first edges of the first and second parts; and

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a second connecting member that extends along the second edges of the first and second parts.

13. The fuel cell system of claim 12 in which each connecting member is pivotably connected to the first and second parts.

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14. The fuel cell system of claim 11 in which the at least one connecting member is pivotably connected to the first and second parts.

15. The fuel cell system of any preceding claim in which the at least one connecting member comprises a recess for an electrical cable for providing power from the fuel cell.

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16. The fuel cell system of any preceding claim in which the housing in the second, expanded configuration forms an open cavity for receiving the removable fuel cartridge.

17. A mobile telecommunication or computing device comprising the fuel cell system of any preceding claim.

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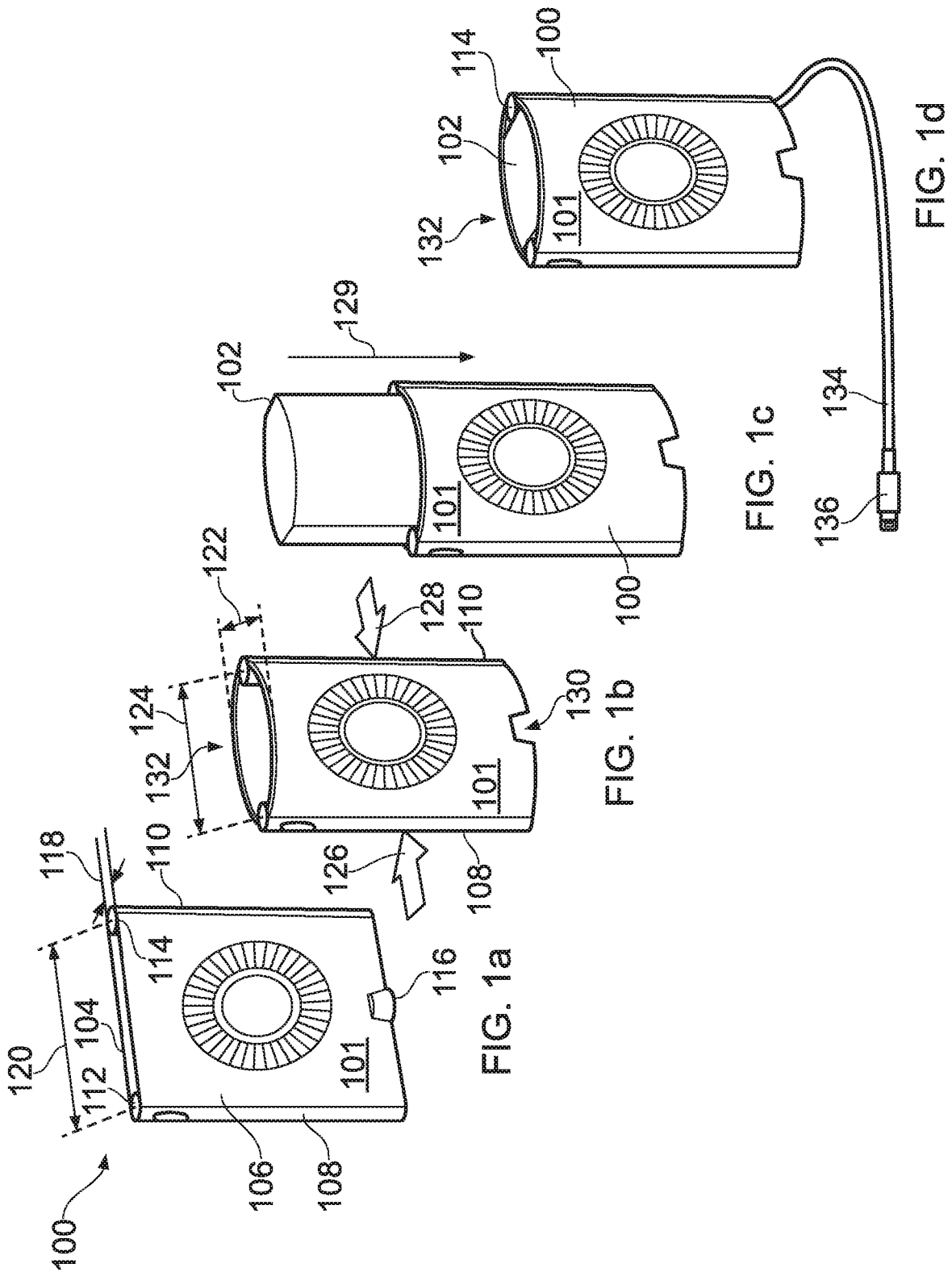
18. A charging apparatus for a mobile telecommunication or computing device, the charging apparatus comprising the fuel cell system of any of claims 1 to 16.

19. A fuel cartridge for the fuel cell system of any of claims 1 to 16.

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20. A fuel cell system, fuel cartridge, charging apparatus, mobile telecommunication or computing device substantially as described herein with reference to the accompanying drawings.

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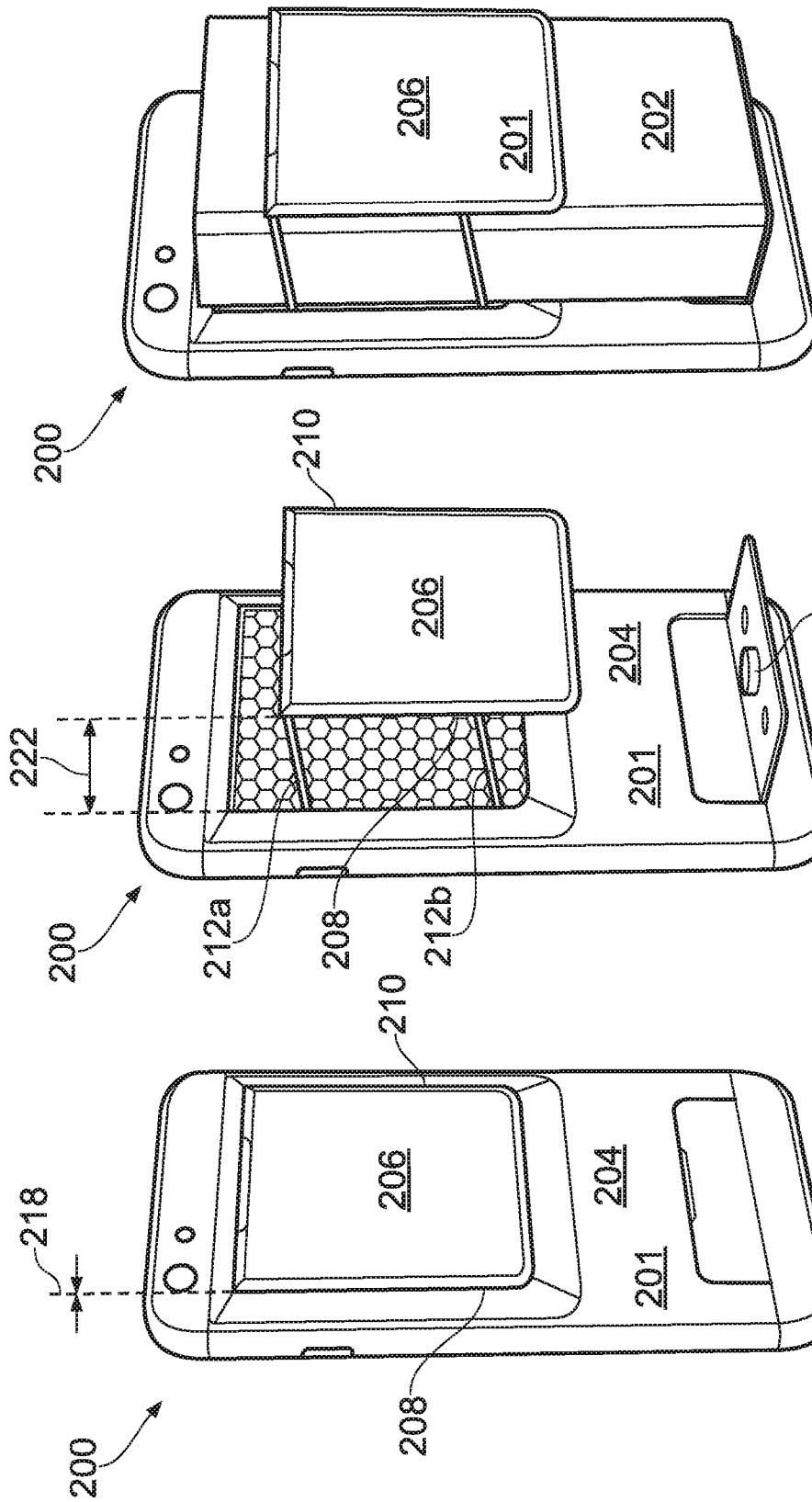


FIG. 2c

FIG. 2b

FIG. 2a

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2016/052143

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01M8/1007 H01M8/04082
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/194992 A1 (BARTON RUSSELL [CA] ET AL) 11 August 2011 (2011-08-11) the whole document	19
X	JP 2009 170340 A (CASIO COMPUTER CO LTD) 30 July 2009 (2009-07-30) paragraphs [0002] - [0004] figures 2,3,6 paragraphs [0031], [0053] - [0055]	1-18,20



Further documents are listed in the continuation of Box C.



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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2011194992 A1	11-08-2011	AU 2011213134 A1	16-08-2012
		BR 112012019892 A2	03-05-2016
		CA 2788534 A1	11-08-2011
		CN 102754265 A	24-10-2012
		EP 2534722 A1	19-12-2012
		HK 1175310 A1	31-12-2015
		JP 5793153 B2	14-10-2015
		JP 2013518805 A	23-05-2013
		JP 2015131759 A	23-07-2015
		KR 20130034006 A	04-04-2013
		US 2011194992 A1	11-08-2011
		US 2014248185 A1	04-09-2014
		WO 2011097198 A1	11-08-2011

JP 2009170340 A	30-07-2009	JP 5211711 B2	12-06-2013
		JP 2009170340 A	30-07-2009
