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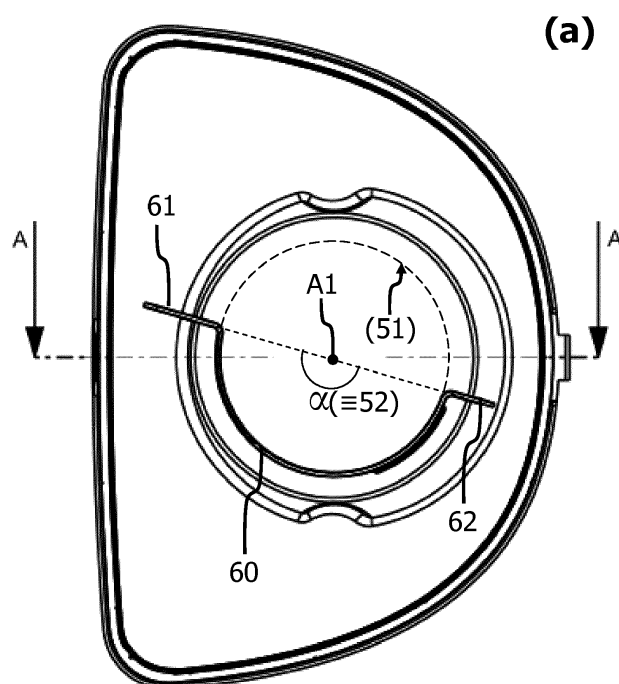
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(54) **CYCLONIC SEPARATOR**

(57) The present invention proposes a cyclone (1) for a household upright reverse cyclone vacuum cleaner; having a mainly cylindrical hollow body (50) provided with a mainly circular outlet (51) opening to a dust tank (100), the cyclone having a cyclone diameter (e), a main axis (A1) which is mainly upright in use, and a height (hi) along said main axis; wherein the cyclone (1) further comprises one or more partial extension(s) (60) to the lateral surface

of the cylindrical hollow body (50), said at least one extension (60) corresponding to a partial arc (52) of the outlet (51) and wherein said at least one extension (60) is provided with a first fin (61) protruding from the extension (60) at an end of the partial arc (52). The present invention further proposes a household vacuum cleaner provided with such cyclone.



Description

Technical Field of the Invention

[0001] The present invention relates to a cyclonic separator, and more specifically to an improved cyclonic separator for vacuum cleaners.

Background of the Invention

[0002] For solid-gas separation (e.g. dust separation), various cyclonic separator designs are employed in different industries, as well as in household vacuum cleaners. US 2015/216 384 discloses an upright vacuum cleaner with a cyclonic separator, and EP 2 820 990 discloses a horizontal vacuum cleaner with an inclined cyclonic separator. Horizontal vacuum cleaners may comprise cyclonic separators with an inclined main axis, or typical upright cyclonic separators designed to perform in a reversed manner (i.e. reversed cyclonic separators). At reversed cyclonic separators, the effects of forces acting during vortex formation differ from those at typical upright cyclonic separators. Therefore a specific design is required to obtain high performance in reversed cyclonic separators.

[0003] Single stage cyclonic separators in the market have a limited efficiency in separation of fine solid (dust) particles (i.e. particles with a diameter of about 0.4 micrometers or smaller) from coarse ones (i.e. particles with a diameter of 4.2 micrometers or larger), therefore such separators require further improvement. Especially low extent of separation of coarse solid particles with higher diameter values causes clogging of fine dust filters which are employed with the aim of filtering fine solid particles. In such case, fine dust filters are at least partly occupied by coarse particles, thus end up by being used ineffectively. Fine dust filters are generally known to be more expensive, therefore this problem can be solved either by frequent replacement of a fine dust filter, or by employing a coarse dust filter upstream with respect to a fine dust filter. Both solutions are problematic by being economically non-feasible; and in the latter case by necessitating a higher volume dedicated for such system of multiple filters.

[0004] More importantly, structural designs of the common cyclonic separators result in improperly balanced accumulation of particles in a respective dust tank. Therefore, base of a tank operated with such cyclonic separator gets disproportionally covered with particles. In such case the tank necessitates shaking during operation for obtaining a proper distribution of particles on its base, or requires emptying and cleaning before being completely filled with particles, thus results in intermit-
tences of operation. Additionally, several positioning restrictions apply to known cyclonic separators to be employed in vacuum cleaners for obtaining acceptable separation results; which restrictions negatively affect the flexibility of industrial designers at designing such vacu-

um cleaners. These issues require a thorough rearrangement of several design parameters concerning cyclonic separators.

Objects of the Invention

[0005] Primary object of the present invention is to overcome the abovementioned shortcomings of the prior art.

[0006] Another object of the present invention is obtainment of a cyclonic separator providing an even distribution of solid particles in a respective dust tank.

[0007] Another object of the present invention is obtainment of a cyclonic separator for increased retention of solid particles.

[0008] A further object of the present invention is provision of an economically advantageous cyclonic vacuum cleaner with improved efficiency in particles retention.

Summary of the Invention

[0009] The present invention proposes a cyclone (1) for a household upright reverse cyclone vacuum cleaner; having a mainly cylindrical hollow body (50) provided with a mainly circular outlet (51) opening to a dust tank (100), the cyclone having a cyclone diameter (e), a main axis (A1) which is mainly upright in use, and a height (hi) along said main axis; wherein the cyclone (1) further comprises one or more partial extension(s) (60) to the lateral surface of the cylindrical hollow body (50), said at least one extension (60) corresponding to a partial arc (52) of the outlet (51) and wherein said at least one extension (60) is provided with a first fin (61) protruding from the extension (60) at an end of the partial arc (52). The present invention further proposes a household vacuum cleaner provided with such cyclone.

Brief Description of the Figures

[0010] The figures, whose brief explanation are herewith provided, are solely intended for providing a better understanding of the present invention and are as such not intended to define the scope of protection or the context in which said scope is to be interpreted in the absence of the description.

Figure 1 shows (a) an exploded view of an assembly of a tank and with a cyclone according to the present invention, and (b) a section view thereof.

Figure 2 shows a side section view of an assembly of a tank with a cyclone according to the present invention.

Figure 3 shows (a) a perspective view of a lid provided with an extension and fins suitable for being coupled with a cyclone to obtain a cyclone according to the present invention, (b) another perspective view

of such lid from a different aspect, (c) a rear view of such lid, and (d) a front view thereof.

Figure 4 shows (a) a view from below of the lid shown in Fig.3, and (b) A-A section view thereof.

Figure 5 shows (a) a view from below of the lid shown in Fig.3, and (b) B-B section view thereof.

Figure 6 shows (a) a view from below of the lid shown in Fig.3, and (b) and (c) show C-C section views thereof from two opposing aspects.

Detailed Description of the Invention

[0011] Referring now the figures outlined before, the present invention proposes a cyclonic separator, and more specifically a cyclonic separator for vacuum cleaners.

[0012] The cyclonic separator (which is hereinafter also called 'cyclone') according to the present invention is intended to be employed in gas-solid separation systems such as horizontal vacuum cleaners. For the best performance in operation, the cyclone according to the present invention is to be positioned mainly upright. This means the cyclone has a longitudinal main axis (A1) which is, in operation, to be aligned mainly parallel to a gravity vector.

[0013] The present invention proposes a cyclone (1) suitable for employing in household upright reverse cyclone vacuum cleaners. The cyclone has a mainly cylindrical hollow body (50) provided with a mainly circular outlet (51) opening to a dust tank (100). As a mainly cylindrical cyclone to be employed in a vacuum cleaner described above, the cyclone has a cyclone diameter (e), a main axis (A1) which is mainly upright in use, and a height (h_i) along said main axis. The cyclone (1) further comprises one or more partial extension(s) (60) to the lateral surface of the cylindrical hollow body (50), said at least one extension (60) corresponding to a partial arc (52) of the outlet (51) and wherein said at least one extension (60) is provided with a first fin (61) protruding from the extension (60) at an end of the partial arc (52).

[0014] Here, the term "lateral surface" should be understood as an inner surface of the cylindrical hollow body, since that is the lateral surface where gas-solid stream to be separated is to be flow on.

[0015] Optionally, at the cyclone according to the present invention, the first fin (61) extends mainly transversely outwards from the extension (60) with respect to the main axis (A1).

[0016] Said at least one extension (60) can be provided with a second fin (62) mainly transversely extending outwards from the extension (60) with respect to the main axis (A1), at the end of the respective partial arc (52) which is distal with respect to said first fin (62).

[0017] Preferably, the partial arc (52) in case of a singular extension (60) or the sum of the partial arcs in case

of plural extensions (60) corresponds to a radial angle (α) within the range between 150° and 210°, preferably within the range between 170° and 190°, more preferably within the range between 175° and 185° around the main axis (A1).

[0018] In a preferred embodiment, the cyclone (1) is at least partly surrounded by a dust tank (100) having an upper opening (101) hermetically sealable by closing said upper opening (101) with a lid (70).

[0019] In an embodiment according to the present invention, the extension (60) is provided on the lid (70), such that the outlet (51) gets at least partly into contact with the extension (60) when the upper opening (101) is closed with the lid (70).

[0020] Alternatively, the extension (60) is provided on the outlet (51), such that the lid (70) gets at least partly into contact with the extension (60) when the upper opening (101) is closed with the lid (70).

[0021] Alternatively, a part of the extension (60) is provided on the lid (70) and the rest of the extension (60) is provided on the outlet (51), such that when the upper opening (101) is closed with the lid (70), the extension (70) is completed from said part and rest of the extension (60).

[0022] In preferred embodiments according to any of the above alternatives, the height (h₂) of the extension (60) in the direction of the main axis (A1) is at least one tenth of the cyclone diameter (e). A laboratory experiment showed that, retention of 95% of solid particles having diameter above 4.5 micrometers in the dust tank is provided by such cyclone. More preferably, the height (h₂) of the extension (60) in the direction of the main axis (A1) is within a range between one sixth and one eighth of the cyclone diameter (e). A respective experiment showed that, retention of 95% of solid particles having diameter above 4.3 micrometers in the dust tank is provided by such cyclone. Such retention ratios can be attributed to enhanced performance and efficiency of the cyclone.

[0023] In a preferred embodiment according to the present invention, contact surfaces of at least one of the first fin (61) and the second fin (62) have a higher roughness when compared with a lateral surface of the cylindrical hollow body, i.e. with an inner surface of the cylindrical hollow body (50). The term "contact surface" here means a surface on which, in operation, a solid-gas mixture to be separated, contacts and flows.

[0024] Accordingly, the present invention further proposes a vacuum cleaner comprising a cyclone according to the above disclosure. Furthermore, the present invention proposes the use of such cyclone (1) in a household vacuum cleaner.

[0025] With the cyclone according to the present invention, solid particles to be separated from an aerosol can be directed in accordance with process-related requirements. For instance, unlike with the cyclones according to prior art, with the cyclone according to the present invention, dust can be evenly collected in a respective dust tank of a household vacuum cleaner com-

prising such cyclone. Pursuant to fluid dynamics around a typical cyclone (lacking the extension and at least the first fin) and a respective tank, dust accumulates around a certain point on the dust tank as mentioned above. Yet, the extension directs the aerosol stream towards (at least the first) fin, and using the Coanda Effect on respective surfaces of fin(s), the aerosol stream is further directed outwards from the cyclone (e.g. into the respective dust tank). Hence, thanks to the cyclone according to the present invention, a cyclone producer would be able to arrange the position(s) of extension(s) and respective fin(s), such that distribution of accumulated solid particles in a dust tank of a respective solid-gas separation system (process) can be advantageously determined and arranged at design step. Such arrangement can be made by selecting the locus of a partial arc (which corresponds to the position of the extension with respect to the outlet of the cyclone) on the full arc (which equals to 180°) corresponding to the circular outlet (51) as exemplified by a displacement angle (x) in Fig. 6(a).

[0026] In an embodiment, the extension (60) is removably coupleable with the cylindrical hollow body (50). In this case, the extension can be coupled to the cylindrical hollow body (50), and then the lid (70) can be mounted to the couple (the cylindrical hollow body with the extension) before operating the cyclone. Alternatively, the extension (60) can be removably coupleable with the lid (70). In this case, the extension (60) can be coupled with the lid (70) and then the couple (the lid with the extension) can be mounted to the cylindrical hollow body (50) before operating the cyclone. Thus the extension can be replaced or bought separately, reducing the maintenance costs of the cyclone.

[0027] Furthermore, at an exemplary experimental vacuum cleaner (shown in the figures) employing a cyclone according to the present invention, the solid particles retention efficiency was found to be increased about 5% compared to that value achieved without the extension and respective fins removed.

[0028] Thus the following objects are achieved by the present invention:

- overcoming the abovementioned shortcomings of the prior art,
- provision of:
 - a cyclonic separator providing an even distribution of solid particles in a respective tank,
 - a cyclonic separator for increased retention of solid particles,
 - a cyclonic separator providing higher design flexibility,
 - an economically advantageous cyclonic vacuum cleaner with improved efficiency in particles

retention.

Claims

1. A cyclone (1) for a household upright reverse cyclone vacuum cleaner; having a mainly cylindrical hollow body (50) provided with a mainly circular outlet (51) opening to a dust tank (100), the cyclone having a cyclone diameter (e), a main axis (A1) which is mainly upright in use, and a height (h_1) along said main axis; **wherein** the cyclone (1) further comprises one or more partial extension(s) (60) to the lateral surface of the cylindrical hollow body (50), said at least one extension (60) corresponding to a partial arc (52) of the outlet (51) and wherein said at least one extension (60) is provided with a first fin (61) protruding from the extension (60) at an end of the partial arc (52).
2. Cyclone according to the claim 1, wherein the first fin (61) extends mainly transversely outwards from the extension (60) with respect to the main axis (A1).
3. Cyclone according to any of the claims 1 or 2, wherein said at least one extension (60) is provided with a second fin (62) mainly transversely extending outwards from the extension (60) with respect to the main axis (A1), at the end of the respective partial arc (52) which is distal with respect to said first fin (62).
4. Cyclone according to any of the claims 1 to 2, wherein the partial arc (52) in case of a singular extension (60) or the sum of the partial arcs in case of plural extensions (60) corresponds to a radial angle (α) within the range between 150° and 210°, preferably within the range between 170° and 190°, more preferably within the range between 175° and 185° around the main axis (A1).
5. Cyclone according to any of the claims 1 to 4, being at least partly surrounded by a dust tank (100) having an upper opening (101) hermetically sealable by closing said upper opening (101) with a lid (70).
6. Cyclone according to the claim 5, wherein the extension (60) is provided on the lid (70), such that the outlet (51) gets at least partly into contact with the extension (60) when the upper opening (101) is closed with the lid (70).
7. Cyclone according to the claim 5, wherein the extension (60) is provided on the outlet (51), such that the lid (70) gets at least partly into contact with the extension (60) when the upper opening (101) is closed with the lid (70).

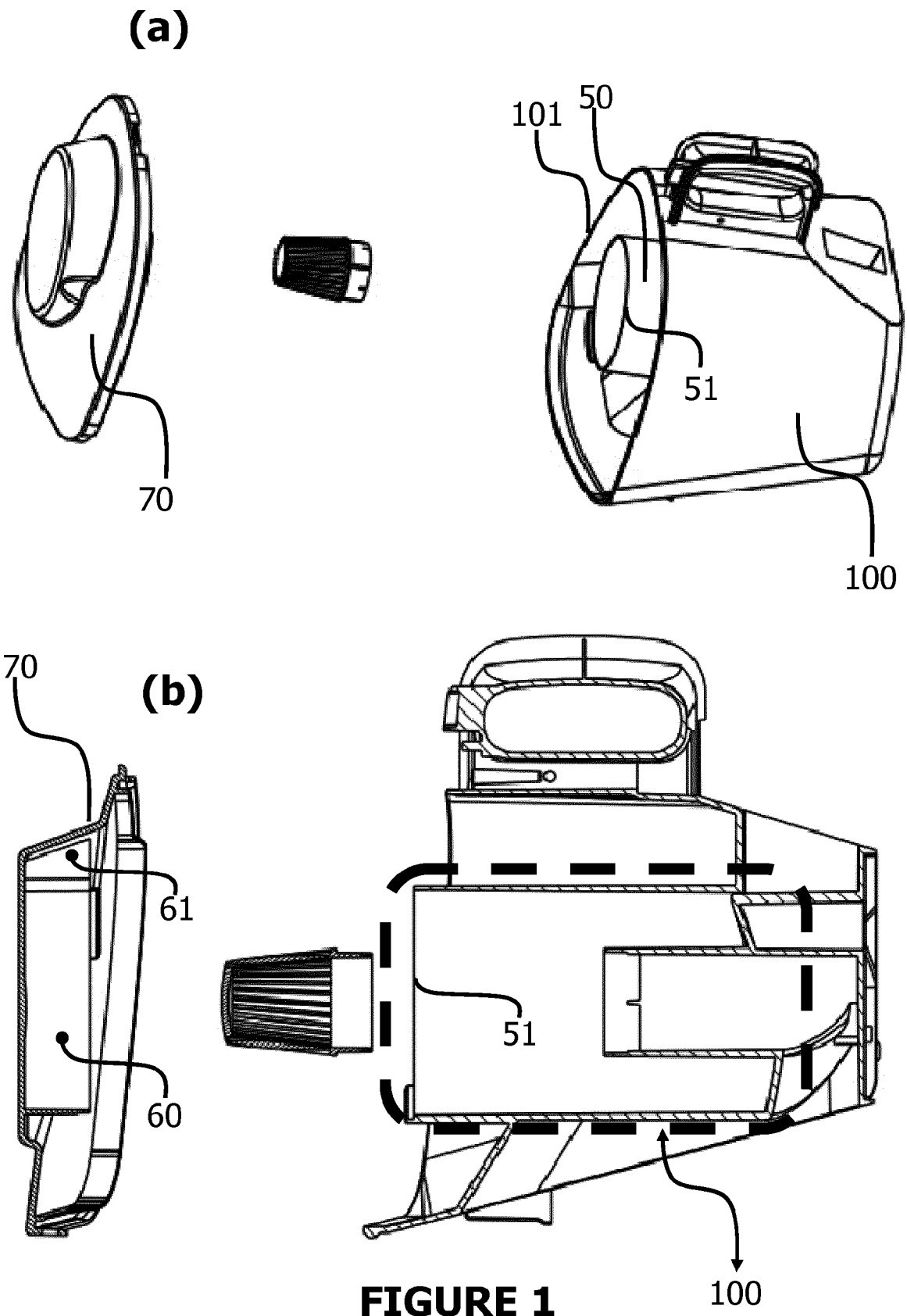
8. Cyclone according to the claim 5, wherein a part of the extension (60) is provided on the lid (70) and the rest of the extension (60) is provided on the outlet (51), such that when the upper opening (101) is closed with the lid (70), the extension (70) is completed from said part and rest of the extension (60). 5
9. Cyclone according to any of the claims 6 to 8, wherein the height (h2) of the extension (60) in the direction of the main axis (A1) is at least one tenth of the cyclone diameter (e). 10
10. Cyclone according to the claim 9, wherein the height (h2) of the extension (60) in the direction of the main axis (A1) is within a range between one sixth and one eighth of the cyclone diameter (e). 15
11. Cyclone according to any of the previous claims, wherein contact surfaces of at least one of the first fin (61) and the second fin (62) have a higher roughness when compared with a lateral surface of the cylindrical hollow body (50). 20
12. Cyclone according to any of the claims 1 to 11, wherein the extension (60) is removably coupleable with the cylindrical hollow body (50). 25
13. Cyclone according to any of the claims 1 to 11, wherein the extension (60) is removably coupleable with the lid (70). 30
14. A household vacuum cleaner comprising a cyclone according to any of the claims 1 to 13.
15. Use of a cyclone (1) according to any of the claims 1 to 11 in a household vacuum cleaner. 35

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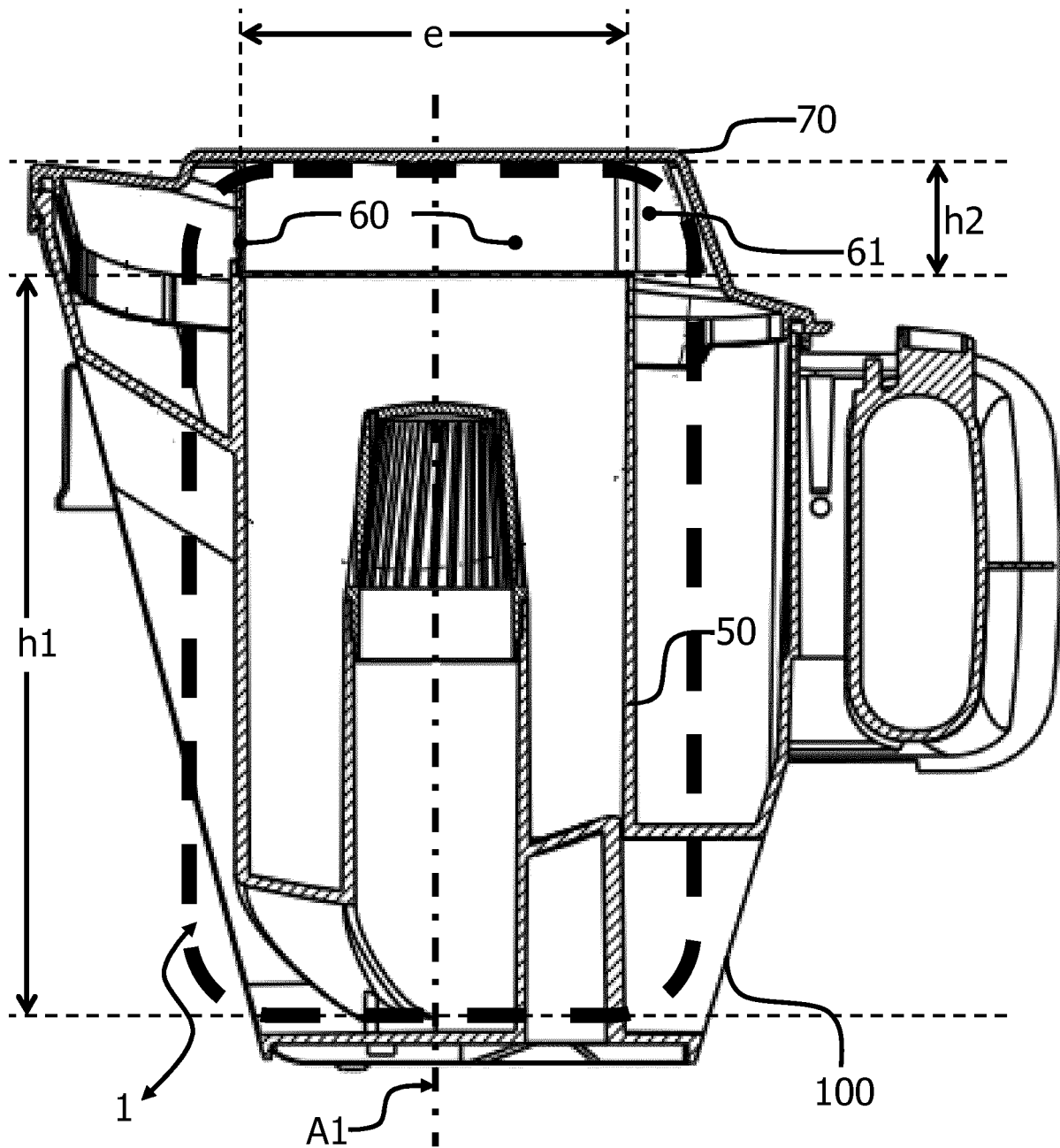


FIGURE 2

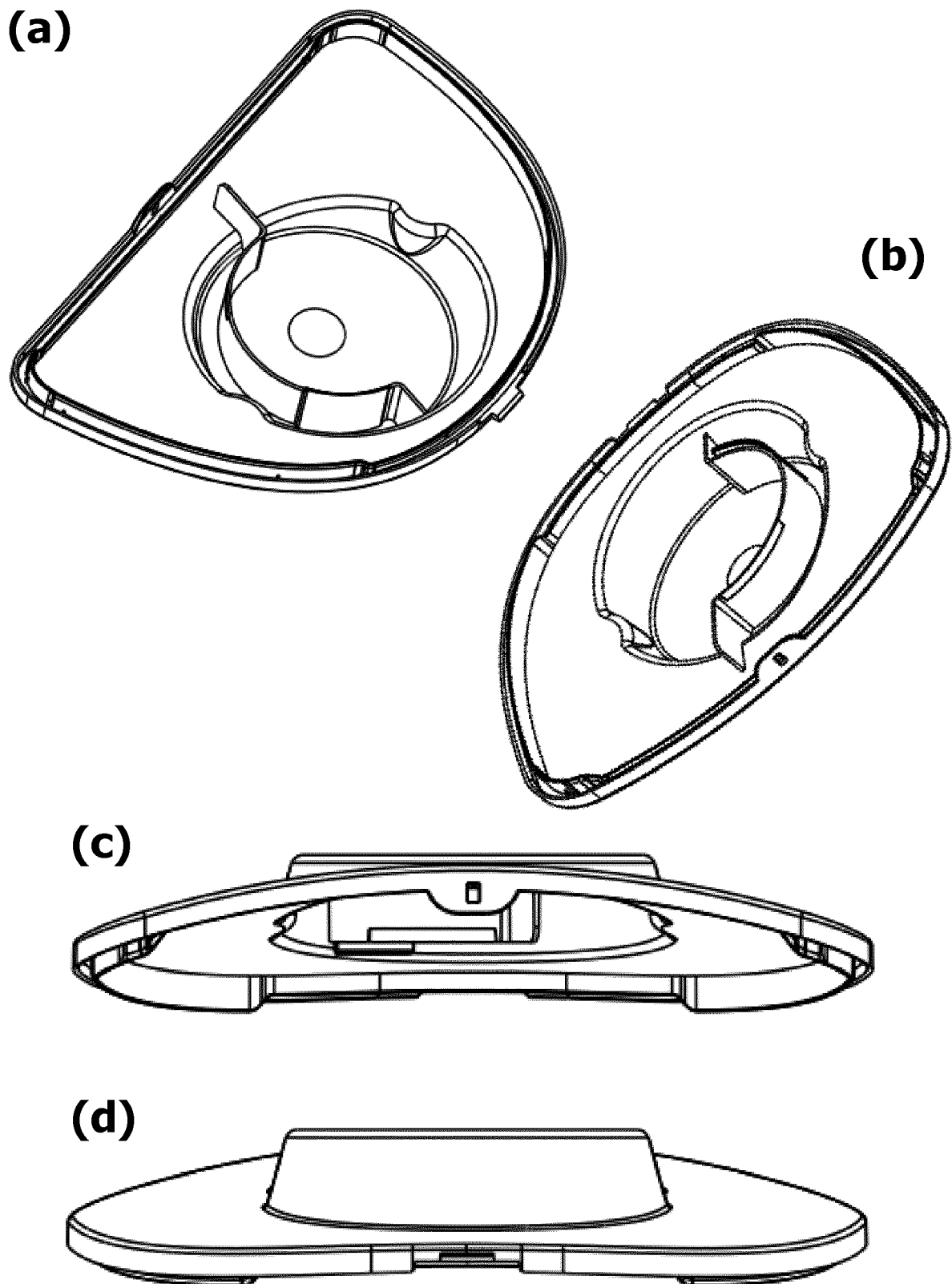


FIGURE 3

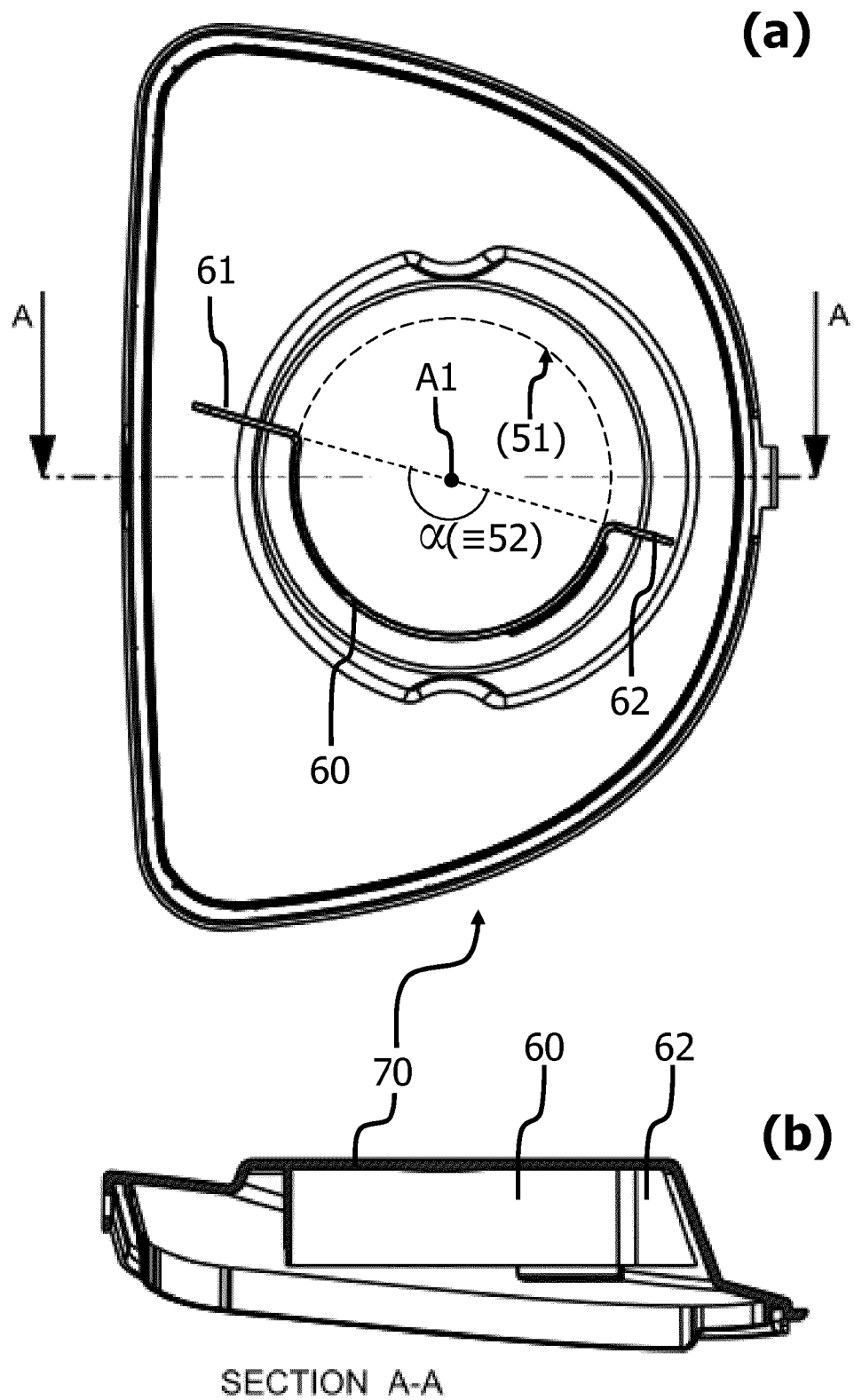


FIGURE 4

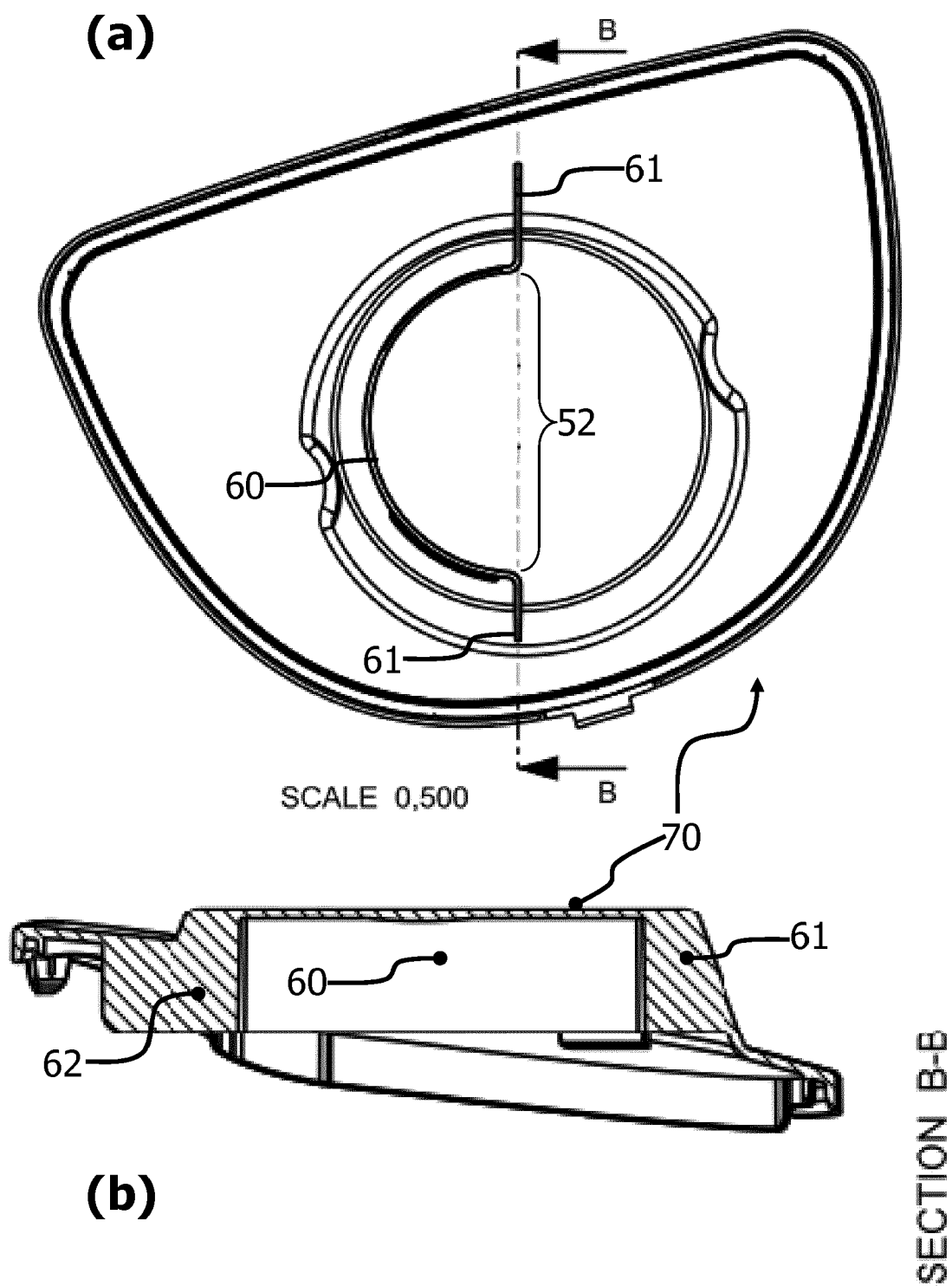


FIGURE 5

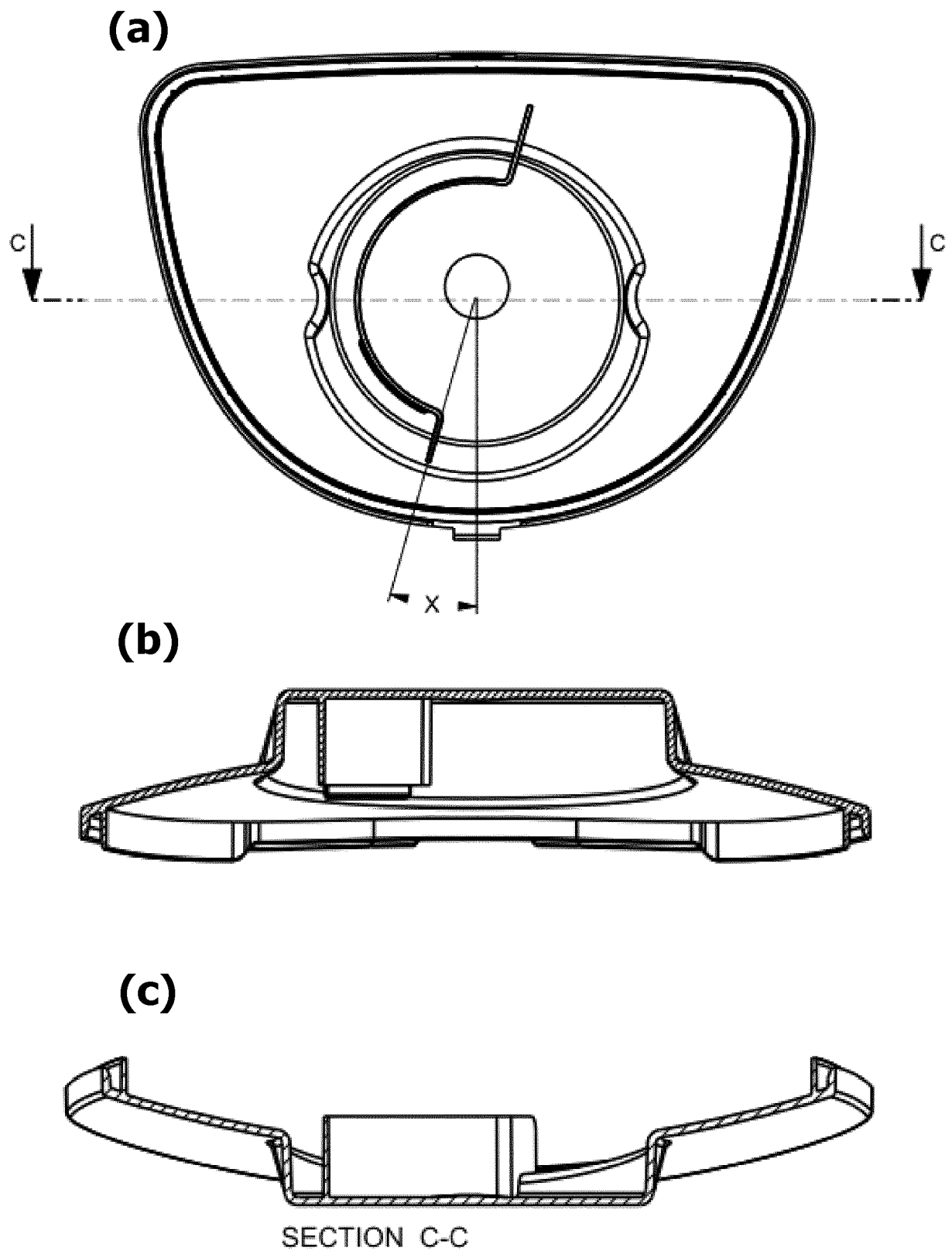


FIGURE 6



EUROPEAN SEARCH REPORT

 Application Number
 EP 16 17 1793

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CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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