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(54) **DEVICE OF RESPIRATORY PHYSIOTHERAPY**

(57) There is disclosed herein a respiratory physiotherapy device (1) for exercising inhalation and exhalation in their natural physiological sequence, which affords estimation of the lung capacity of the exercising individual.

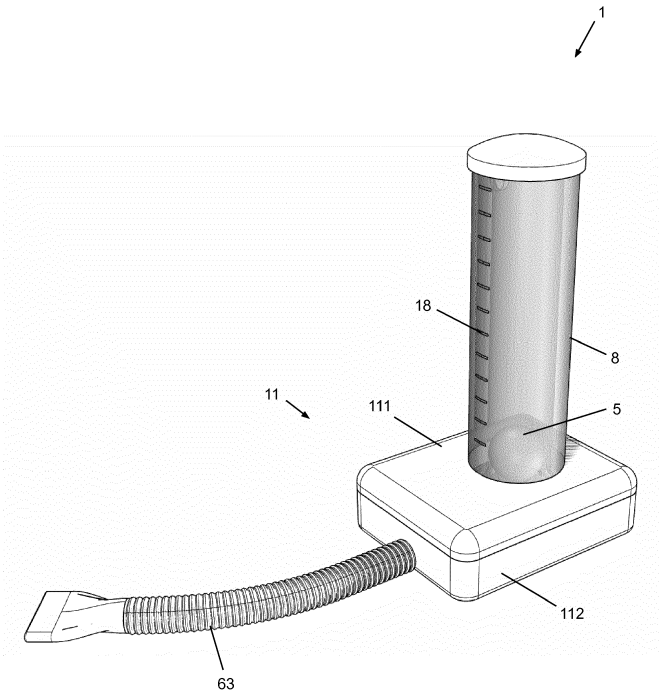

Fig. 1

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Description

[0001] A respiratory physiotherapy device is disclosed herein.

[0002] Namely, a passive respiratory device is disclosed, i.e. of the type having no mechanical ventilation devices.

[0003] The device as described hereinafter is particularly suitable for breathing exercise, aimed at exercising the muscles of respiration (i.e. the muscles of inhalation and exhalation), namely the accessory muscles of respiration.

[0004] As used herein the "accessory muscles of respiration" are intended as the muscles (of inhalation and exhalation) involved in forced respiration.

[0005] The device as described hereinafter can also increase oxygen saturation in blood.

[0006] The use of the device as described hereinafter can also add volume and elasticity to bronchi, bronchioles and alveoli.

[0007] Also, the device as described hereinafter is suitable to provide indications about certain lung parameters, such as instantaneous inhalation and exhalation flow rates.

[0008] The device as described herein may be also useful to obtain an indication of lung capacity and resistance to exhalation.

[0009] US 3 695 608, US 4 025 070, US 4 138 105, US 4 114 607 and US 4 183 361 disclose devices for exercising inhalation muscles, namely the accessory muscles of inhalation.

[0010] US 4 171 804, US 2014/150801 and US 9 561 399 B2 disclose devices for exercising exhalation muscles, namely the accessory muscles of exhalation.

[0011] US 3 898 987 discloses a device for measuring the volume of air inhaled by a patient.

[0012] The device disclosed by US 3 898 987 can be used both in natural breathing conditions and when supplementing the activity of the muscles of respiration with a positive-pressure mechanical ventilation device.

[0013] Prior art respiratory physiotherapy devices have various drawbacks.

[0014] The object of the invention is to provide a respiratory physiotherapy device that at least partially obviates the drawbacks of the prior art.

[0015] In particular, one object of the invention is to provide a respiratory physiotherapy device that can exercise both inhalation and exhalation muscles, in their natural physiological sequence.

[0016] More particularly, one object of the inventor is to provide a device that can exercise both the accessory muscles of inhalation and the accessory muscles of exhalation, in their natural physiological sequence.

[0017] Certain possible embodiments of a respiratory physiotherapy device are described below with reference to the accompanying drawings in which:

- Figure 1 is a perspective view of a respiratory physiotherapy device;
- Figure 2 is a sectional perspective view of the device of Figure 1, as taken along a first plane;
- Figure 3 is a sectional perspective view of the device of Figure 1, as taken along a second plane;
- Figure 4 is a perspective view of a component of the device of Figure 1;
- Figure 5 is a further perspective view of the same component of Figure 4;
- Figure 6 is a sectional perspective view of the device of Figure 1, as taken along a third plane;
- Figure 7 is a sectional view of the device of Figure 1, as taken along a fourth plane;
- Figure 8 is a sectional view of the device of Figure 1 as taken along a fifth plane;
- Figure 9 is a sectional perspective view of the respiratory physiotherapy device;
- Figure 10 shows a non-return valve as used in the device of Figure 1, when closed; and
- Figure 11 shows a non-return valve as used in the device of Figure 1, when open.

[0018] Referring to the accompanying drawings and to the reference numbers in the drawings, numeral 1 generally designates a respiratory physiotherapy device for exercising inhalation and exhalation in their natural physiological sequence.

[0019] Therefore, the device 1 allows the user to complete entire respiratory cycles without acting on the device, i.e. in seamless manner.

[0020] The device can particularly exercise the accessory muscles of respiration, namely the muscles of respiration involved in forced respiration.

[0021] The device 1 comprises a chamber 2 which extends along a substantially vertical.axis X.

[0022] The chamber 2 has a lower end 3 and an upper end 4.

[0023] In the illustrated example, the chamber 2 has rigid walls and hence maintains a constant volume during the operation of the device 1.

[0024] The lower end 3 of the chamber 2 communicates with a first air inflow opening 31, for the inflow of exhaled air and with a second air inflow opening 32 for the inflow of inhaled air.

[0025] The upper end 4 of the chamber 2 communicates with a first air outflow opening 41 for the outflow of exhaled air, and with a second air outflow opening 42 for the outflow of inhaled air.

[0026] The air inhaled and exhaled by the patient during use of the device 1 always flows through the chamber 2 upwards, i.e. from the lower end 3 to the upper end 4.

[0027] A body is provided in the chamber 2, between the lower end 3 and the upper end 4, and is vertically movable upwards when impinged upon by the inhaled or exhaled air that rises through the chamber 2, against its own weight force.

[0028] The flow of air inhaled and exhaled by the patient directly contacts the moving body 5 which impedes

the flow of air in the chamber 2 and forces the user to exercise the accessory muscles of inhalation and exhalation, namely the muscles of forced respiration.

[0029] The position reached by the moving body 5 may be indicative of the performance of the respiratory system of the patient, e.g. of the inhalation and exhalation flow rates.

[0030] In order to create an air flow in the chamber 2, the device 1 is equipped with a duct 6 (connected to the mouth of the patient) which is used to inhale and exhale the air that flows through the chamber 2 and impinges upon the moving body 5.

[0031] For this purpose, as best described hereinafter, the duct 6 is in communication with the first inflow opening 31 (for the inflow of exhaled air into the chamber 2) and with the second outflow opening 42 (to allow the outflow of inhaled air from the chamber 2).

[0032] The inhalation and exhalation duct 6 may be connected to a flexible hose 63 which terminates with a mouthpiece, to allow inhalation and exhalation.

[0033] The device 1 comprises an inlet hole 632, in communication with the second air inflow opening 32, for the inhaled chamber to flow into the chamber 2 from the outside.

[0034] The device 1 comprises an outlet hole 641, in communication with the first air outflow opening 41, for the exhaled air to be exhausted to the outside after flowing out of the chamber 2.

[0035] The first inflow opening 31 for the inflow of air into the chamber 2 is connected to the duct 6 via a first non-return valve 731 which only opens when air is exhaled.

[0036] The first outflow opening 41 for the outflow of air from the chamber 2 is in communication with the outlet hole 641 via a second non-return valve 741 which only opens when air is exhaled.

[0037] The second inflow opening 32 for the inflow of air into the chamber 2 is in communication with the inlet hole 632 via a third non-return valve 732 which only opens when air is inhaled.

[0038] The second outflow opening 42 for the outflow of air from the chamber 2 is in communication with the duct 6 via a fourth non-return valve 742 which only opens when air is inhaled.

[0039] During exhalation, the first non-return valve 731 and the second non-return valve 741 open and the third non-return valve 732 and the fourth non-return valve 742 close.

[0040] On the other hand, during inhalation, the first non-return valve 731 and the second non-return valve 741 are closed and the third non-return valve 732 and the fourth non-return valve 742 are open.

[0041] Thus the air flow in the chamber 2, during the entire exhalation cycle is always directed upwards.

[0042] In other words the air flow generated in the chamber 2 is directed upwards during both inhalation and exhalation.

[0043] In the illustrated example, the chamber 2 has a frustoconical profile and the height reached by the moving body 5 in the chamber 2 is related to the flow rate of the air that flows through the chamber 2.

[0044] Thus, the moving body 5 takes a position of equilibrium when its weight is balanced by the thrust of the air flow.

[0045] In the illustrated example, the chamber 2 is formed inside a hollow body 23 (e.g. a body having a cylindrical outer shape) which is made of a transparent material, to show the position of the moving body 5 in the chamber 2.

[0046] In the illustrated example, the chamber 2 has an upwardly increasing tapered cross section, e.g. a frustoconical section, and the moving body 4 has a generally spherical form.

[0047] Therefore, in the illustrated example the moving body 5 in the chamber 2 acts as a variable-area flowmeter or rotameter.

[0048] The moving body 5 opposes resistance to the air that flows in chamber 2 and forces the user to use the muscles of inhalation and exhalation.

[0049] At the end of each inhalation and exhalation phase, the weight force tends to push the moving body 5 back downwards, in its rest position.

[0050] The maximum height that can be reached by the moving body 5 provides an indication of the maximum lung capacity of the user in the inhalation phase and in the exhalation phase.

[0051] The moving body 5 remains in the lifted position for a time that is proportional to the maximum capacity of the lungs of the user.

[0052] In a possible embodiment, the hollow body 23 is encircled by a second hollow body 8, also made of transparent material, thereby defining an annular chamber 81 that surrounds the chamber 2.

[0053] In a possible embodiment the hollow body 23 and the hollow body 8 are two coaxial tubular elements closed at the top by a cap 85.

[0054] The cap 85 may be joined to the upper end of the hollow body 8 by means of seals (not shown) to ensure air-tightness.

[0055] In an alternative embodiment (see Figure 9) the hollow body 8 is closed at its top.

[0056] The annular chamber 81 communicates at its top with the upper end 4 of the chamber 2 via at least one opening 231 formed in the upper part of the hollow body 23.

[0057] At the bottom, the chamber 81 communicates with the first air outflow opening 41 for the outflow of exhaled air, and with the second air outflow opening 42 for the outflow of inhaled air.

[0058] The exhaled air that flows out of the first outflow opening 41 flows through the second non-return valve 741, whereas the inhaled air that flows out of the second outflow opening 42 flows through the fourth non-return valve 742.

[0059] The device 1 may comprise a graded scale 18 to determine the vertical position of the moving body 5.

[0060] This allows the user to estimate the improvement of his/her lung performance over time, after the exhalation exercises.

[0061] In the illustrated embodiment the graded scale 18 is formed on the wall of the hollow body 8.

[0062] In a possible embodiment the pneumatic resistance between the duct 6 and the outlet opening 641 (for the exhalation phase) and the pneumatic resistance between the duct 6 and the inlet opening 632 (for the inhalation phase) may be adjusted.

[0063] In a possible embodiment the pneumatic resistance is adjusted by adjusting the passage section between the upper end 4 of the chamber 2 and the annular chamber 81.

[0064] For example the cap 85 may be designed to be rotated about the axis X and to have a closure member for varying the passage section of the opening 231 formed on the upper part of the hollow body 23.

[0065] In the illustrated example the lower end of the hollow body 23 and the hollow body 8 are fixed to a base 11.

[0066] In the illustrated example the base 11 ha a hollow interior and comprises an upper half-shell 111 and a lower half-shell 112 which are joined, for example, by means of quick snap connectors.

[0067] In the illustrated example the two half shells 111, 112 are formed with a substantially and/or generally rigid material, for example a thermoplastic material.

[0068] In the illustrated example the upper half shell 111 of the base 11 has a seat 12 for receiving of the lower ends of the hollow body 23 and the hollow body 8.

[0069] In the illustrated example the duct 6 is rigidly joined to the lower half-shell 112.

[0070] In the illustrated example the seat 12 is specially shaped to ensure form-fit with the lower ends of the hollow body 23 and the hollow body 8.

[0071] The seat 12 has the first inflow opening 31 for the inflow of exhaled air into the chamber 2, and the second inflow opening 32 for the inflow in inhaled air into the chamber 2 formed therein.

[0072] The seat 12 also has the first outflow opening 41 for the outflow of exhaled air and the second outflow opening 42 for the outflow of inhaled air formed therein

[0073] The inflow openings 31, 32 are situated within the section of the chamber 2, whereas the outflow openings 41, 42 are situated within the section of the annular chamber 81.

[0074] In the illustrated example, the inlet hole 632 for the air inhaled from the outside into the chamber 2 to flow into the chamber, and the outlet hole 641, for the exhaled air to be exhausted to the outside after flowing out of the chamber 2, are formed in the wall of the lower half-shell 112.

[0075] The non-return valves 731, 732, 741, 742 are valves that allow air to flow in one direction only.

[0076] In the illustrated embodiment the non-return valves 731, 732, 741, 742 are all located inside the base 11.

[0077] The non-return valves 731, 732, 741, 742 may be formed with flexible diaphragms having cuts formed throughout their thickness.

[0078] The full-thickness cuts defines edges that are normally closed and tend to move apart from each other and create a passage lumen, when a pressure difference is generated between the two opposite faces of the membrane.

[0079] At each cut, a perforated or grated support surface is created on one side of the diaphragm, to prevent the edges of the cut to be lifted in one direction.

[0080] As a result, the lumen only opens if the side of the diaphragm that faces the perforated or grated surface is at a pressure above the pressure on the opposite side of the diaphragm.

[0081] In the illustrated example the first, second and third non-return valves 731, 732, 741 are formed with a first diaphragm 7a having three distinct full-thickness cuts.

[0082] In the illustrated example the fourth non-return valve 742 is formed with a second diaphragm7b with a full-thickness cut..

[0083] The first diaphragm 7a is placed in a first seat 1121, formed in the lower half-shell 112, which is in communication with the duct 6 (via an opening 61), with the outlet opening 641 and with the inlet opening 632.

[0084] A frame 91 projects out of the first or upper half-shell 111 toward the first seat 1121, to thereby the outer edges of the first diaphragm 7a and ensure air-tightness.

[0085] The first seat 1121 has a perforated portion therein, to prevent the second non-return valve 641 from opening when the user is in the inhalation phase.

[0086] The frame 91 has therein a first grated portion to prevent the first non-return valve 731 from opening during the inhalation phase, and a second grated portion to prevent the third non-return valve 732 from opening during the inhalation phase.

[0087] The second diaphragm 7b is placed in a second seat 1122 formed in the lower half-shell 112, which is in communication with the duct 6 (via an opening 62).

[0088] The edges of the second diaphragm7b are compressed by a frame 92 that projects out of the first half-shell 111 and faces the second seat 7b.

[0089] The frame 92 has a perforated surface therein, which prevents the fourth non-return valve 742 from opening during the exhalation phase.

[0090] The diaphragms 7a, 7b can be made, for example, of medical grade silicone or medical grade silicone-based materials, polyurethane or other flexible polymeric materials and may have an average thickness ranging, for example, from 0.5 mm to 4 mm.

[0091] In an alternative embodiment (not shown), the four non-return valves 731, 732, 741, 742 are all formed with a single diaphragm made of a flexible material.

[0092] In a possible embodiment, the half shells 111, 112 of the base 11 are made of a transparent material and the diaphragms 7a, 7b of the non-return valves 731, 732, 741, 742 are made of a colored material.

[0093] This allows the user to see the operation of the non-return valves 731, 732, 741, 742 during use of the device 1.

Claims

1. A respiratory physiotherapy device (1) for exercising inhalation and exhalation in their natural physiological sequence, comprising

a) a chamber (2) extending along a substantially vertical axis X, and having a lower end (3) and an upper end (4);

a1) said lower end (3) of said chamber (2) being in communication with a first air inflow opening (31) for the inflow of exhaled air at said lower end (3) of said chamber (2);
a2) said lower end (3) of said chamber (2) being in communication with a second air inflow opening (32) for the inflow of inhaled air at said lower end (3) of said chamber (2);
a3) said upper end (4) of said chamber (2) being in communication with a first air outflow opening (41) for the outflow of exhaled air from the upper end (4) of said chamber (2);
a4) said upper end (4) of said chamber (2) being in communication with a second air outflow opening (42) for the outflow of exhaled air from the lower end (4) of said chamber (2);
a5) said chamber (2) being designed to have air upwardly flowing therethrough during both inhalation and exhalation;

b) a body (5) within said chamber (2), which is vertically movable, said body (5) being adapted to rise when said chamber (2) has air flowing therethrough upwards in said chamber (2);
c) a duct (6) for exhalation and inhalation of air;
d) an outlet hole (641), in communication with said first air outflow opening (41) for the outflow of air from said chamber (2), to exhaust the exhaled air from said device (1);
e) an inlet hole (632), in communication with said second air inflow opening (32), for the inhaled chamber to flow into said chamber (2);
f) said first inflow opening (31) for the inflow of air into the chamber (2) being connected to said duct (6) via a first non-return valve (731);
g) said first outflow opening (41) for the outflow of air from the chamber (2) being connected to said outlet hole (641) via a second non-return valve (741);
h) said second inflow opening (32) for the inflow of air into the chamber (2) being connected to said inlet hole (632) via a third non-return valve (732);
i) said second outflow opening (42) for the outflow of air from the chamber (2) being connected to said duct (6) via a fourth non-return valve (742).

2. A device as claimed in claim 1, wherein said chamber (2) is formed inside a hollow body (23) which is at least partially made of transparent material, to show the position of said movable body (5) inside said chamber (2).

3. A device as claimed in claim 2, further comprising a graded scale (18) to determine the vertical position of said moving body (5).

4. A device as claimed in claim 1 or 2 or 3, wherein said chamber (2) has an upwardly increasing tapered cross section and wherein said moving body (5) has a spherical shape.

5. A device as claimed in claim 4, wherein said hollow cylindrical body (23) is encircled by a second hollow cylindrical body (8) made of transparent material, thereby defining an annular chamber (81),
said annular chamber (81) being in communication with said upper end (4) of said chamber (2),
said annular chamber (81) being in communication with said inlet hole (632) via said third non-return valve (732),
said annular chamber (81) being in communication with said discharge hole (641), through said second non-return valve (741).

6. A device as claimed in claim 5, wherein said hollow cylindrical body (23) and said second hollow cylindrical body (8) are two coaxial tubular elements closed at their top by a cap (85) and wherein said annular chamber (81) communicates at its top with the upper end (4) of the chamber (2) via at least one opening (231) formed in the upper part of said hollow body (23).

7. A device as claimed in claim 6, wherein said cap (85) can be rotated to control a closure member that can open or close said at least one opening (231) formed in the upper part of said hollow body (23).

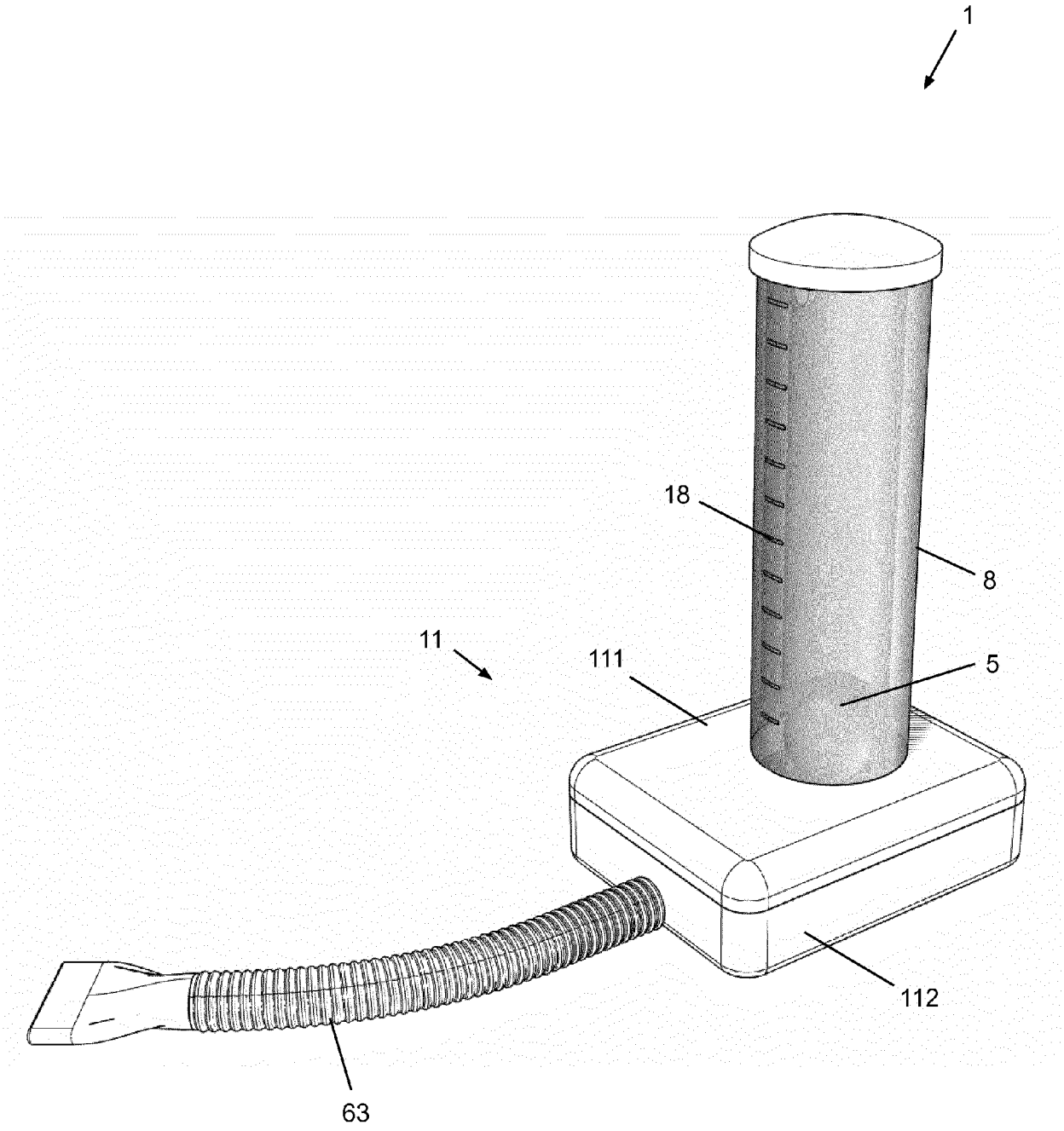

Fig. 1

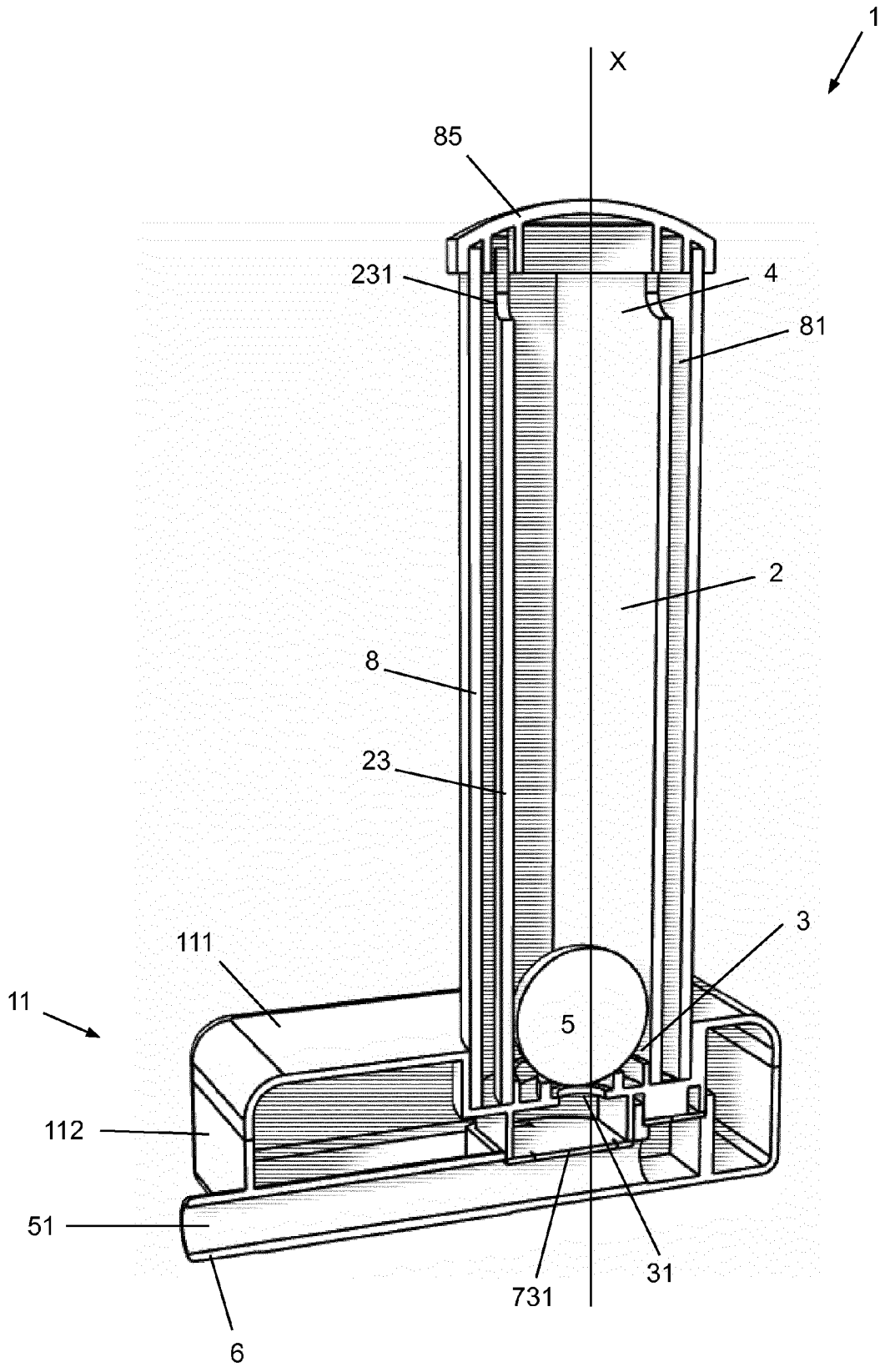

Fig. 2

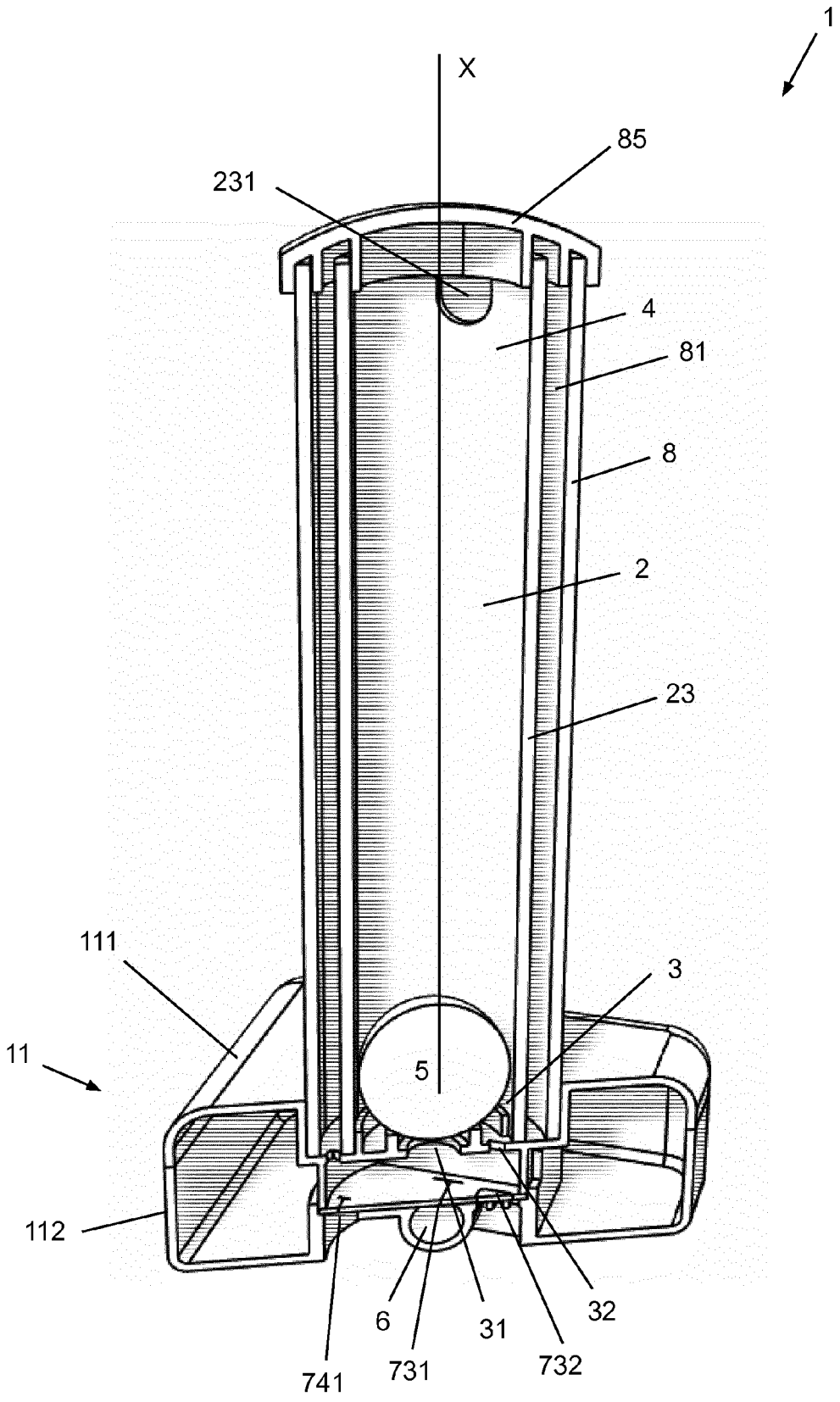

Fig. 3

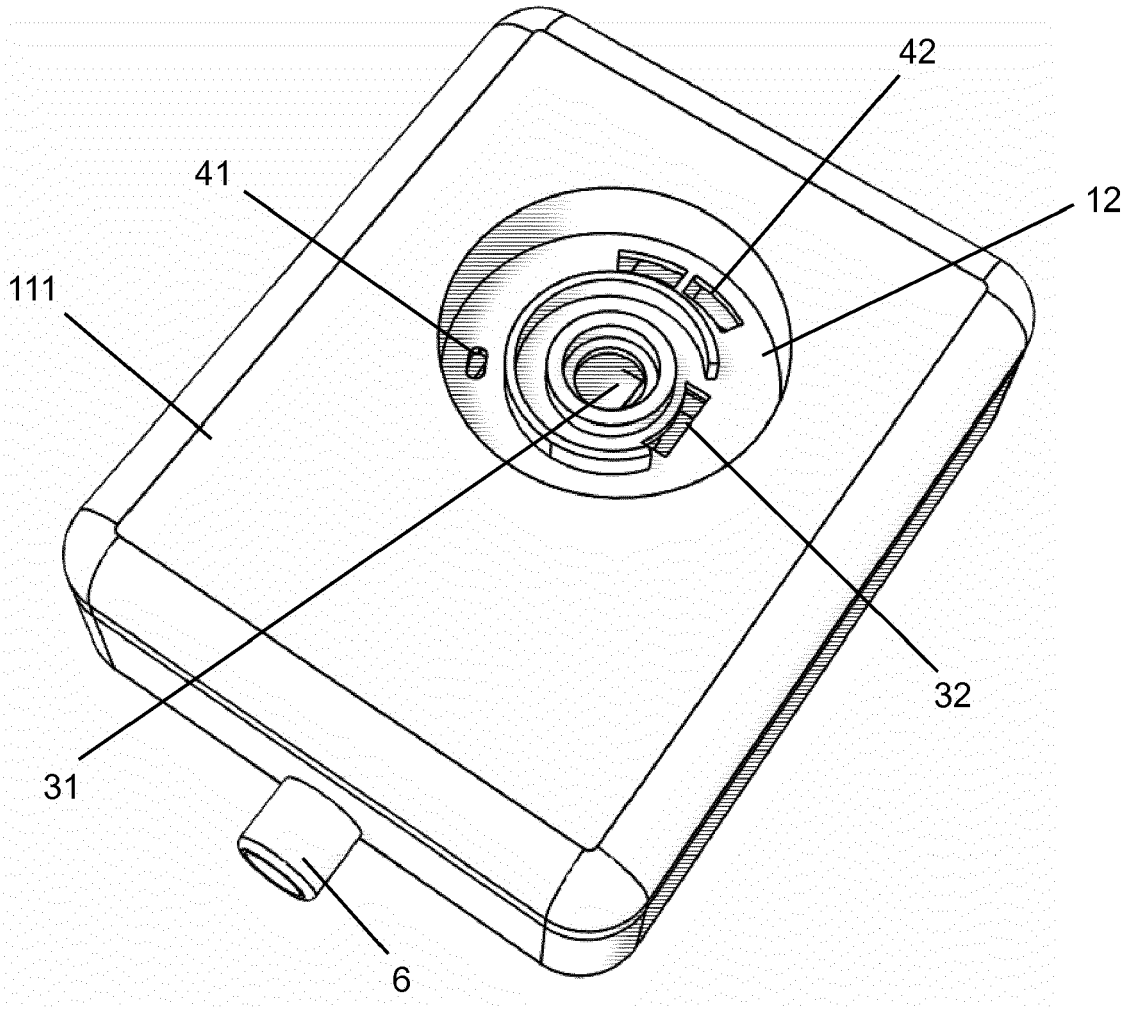

Fig. 4

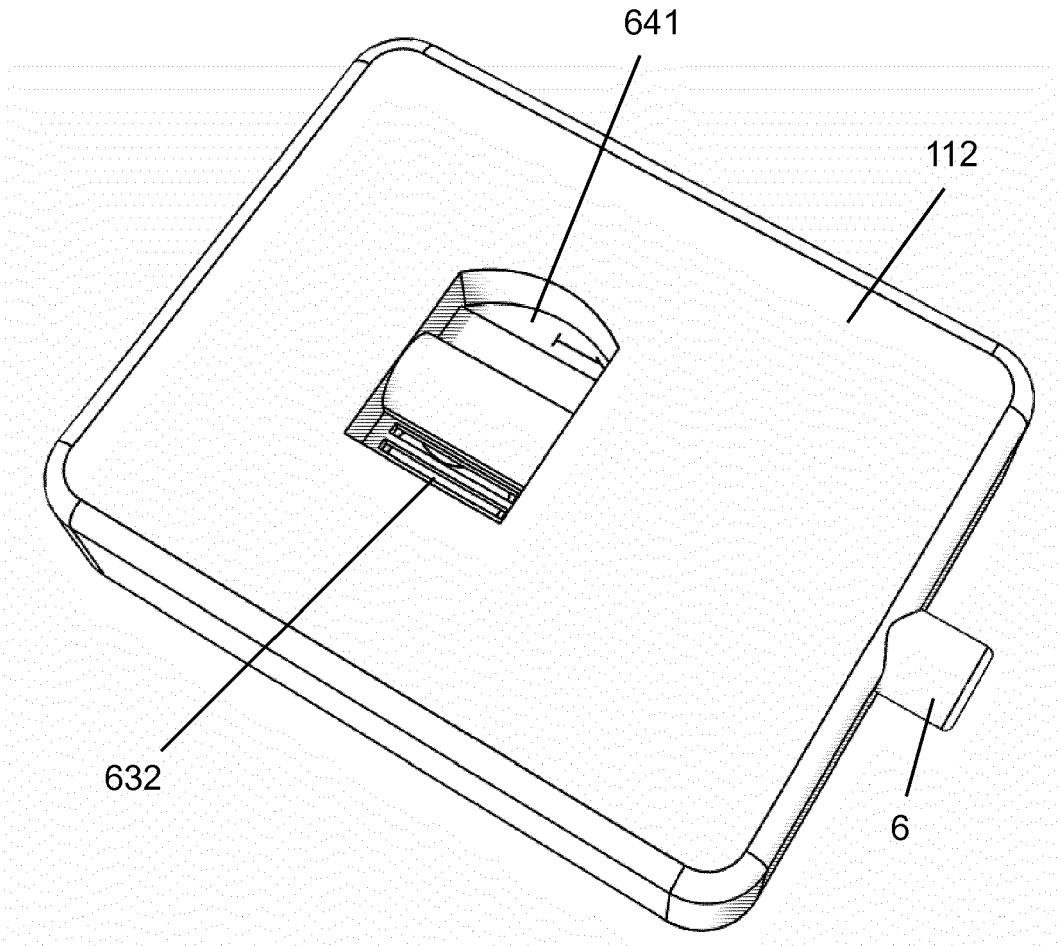

Fig. 5

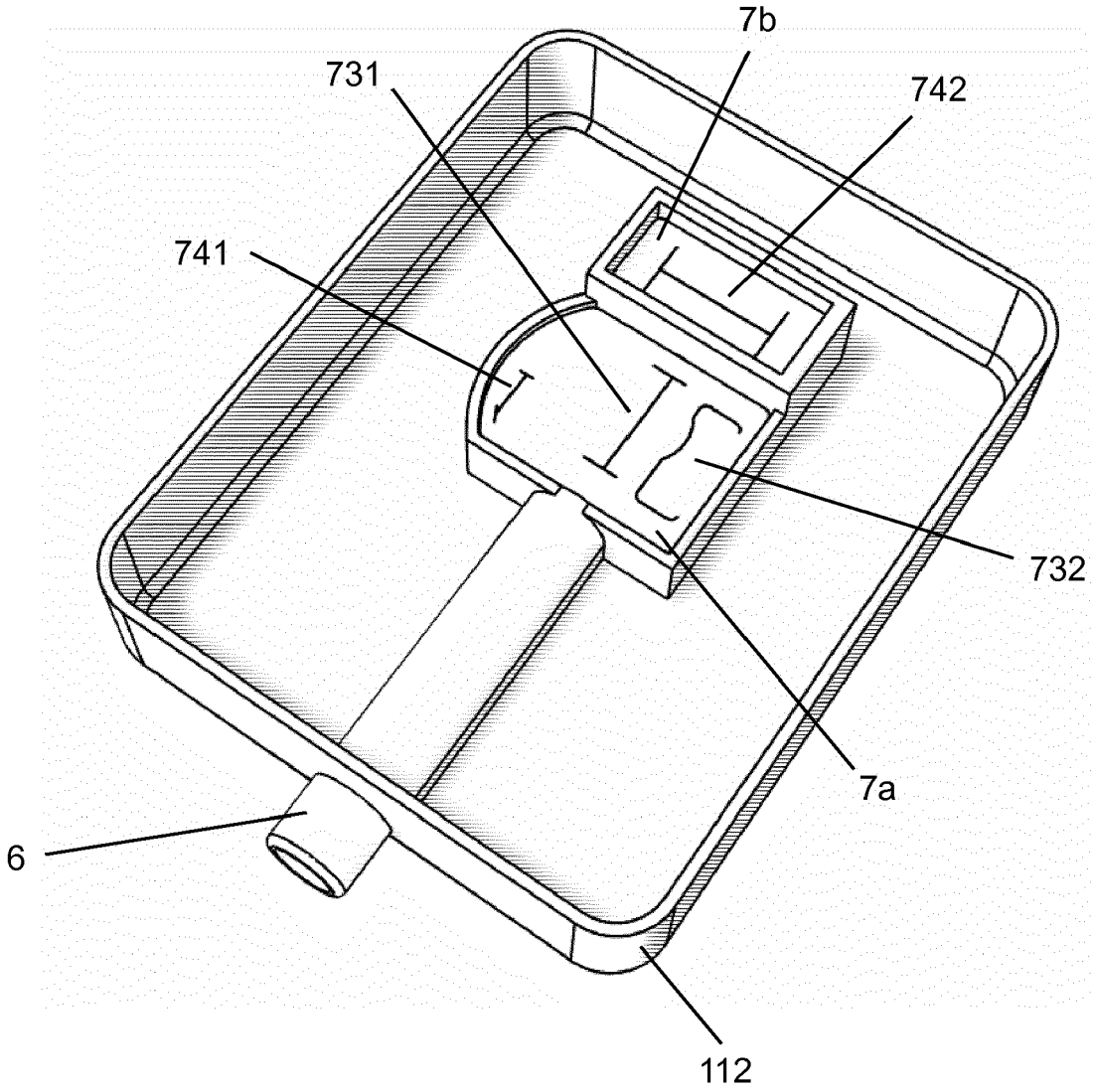

Fig. 6

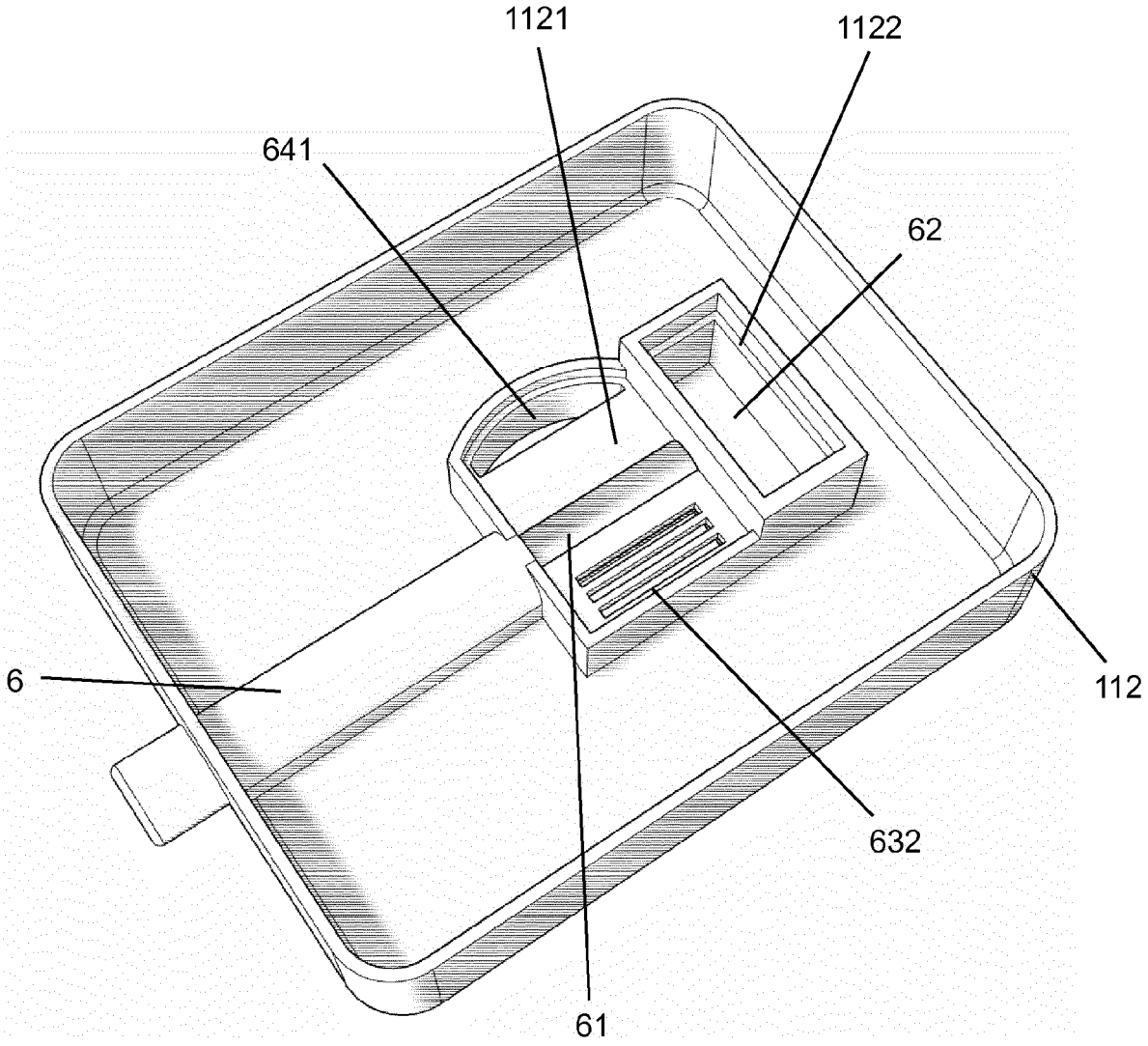

Fig. 7

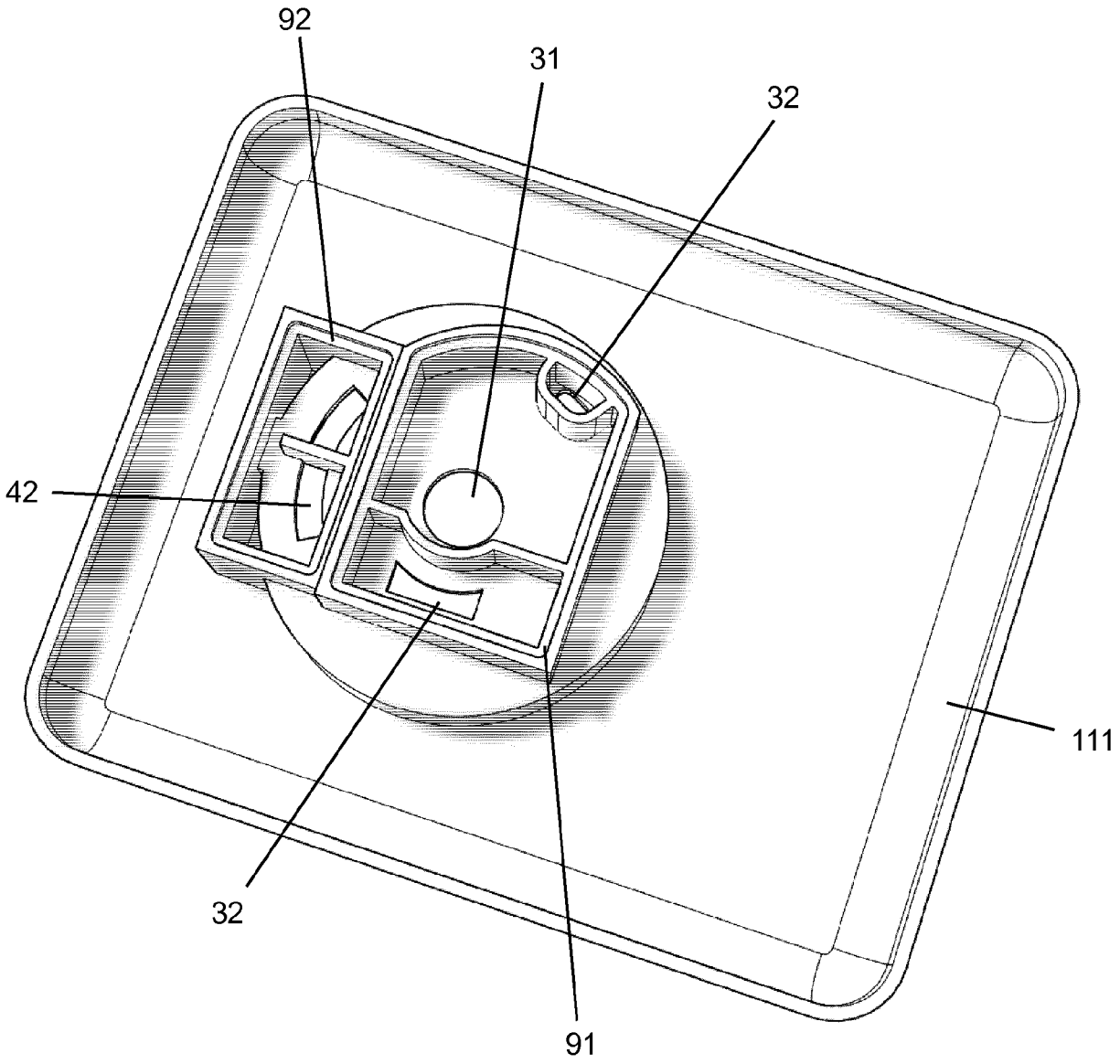

Fig. 8

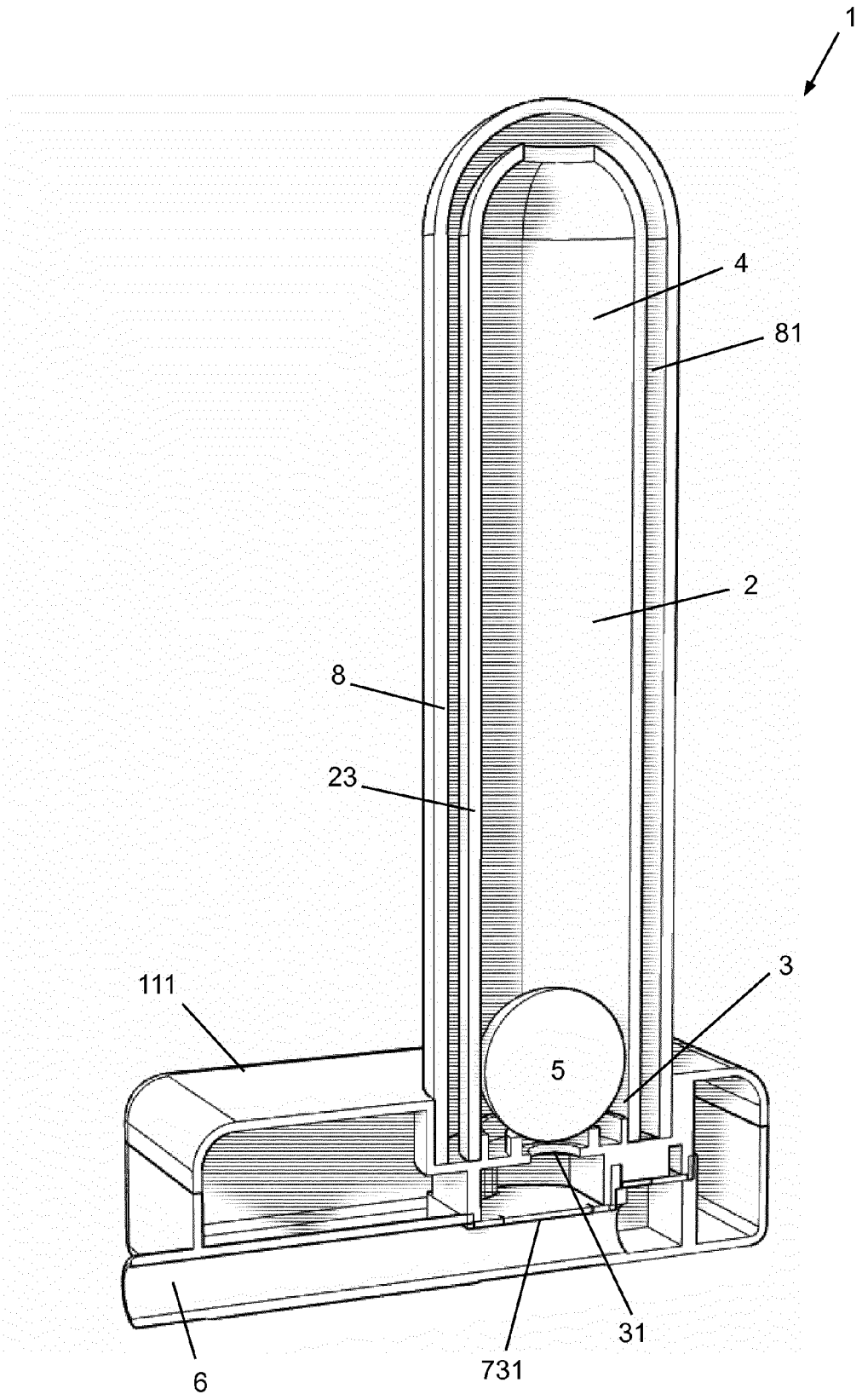

Fig. 9

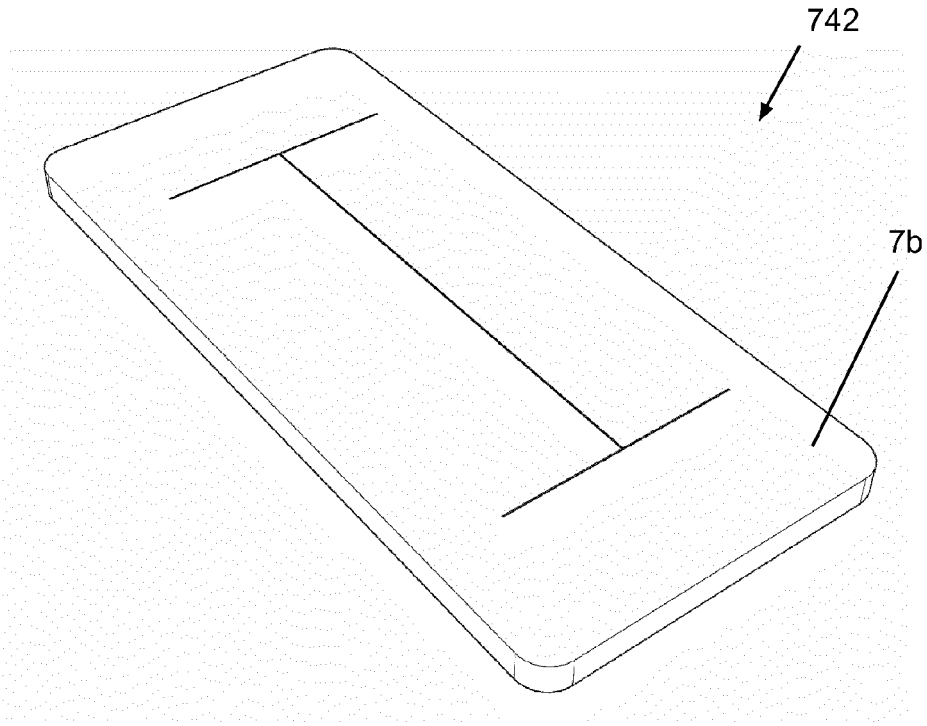

Fig. 10

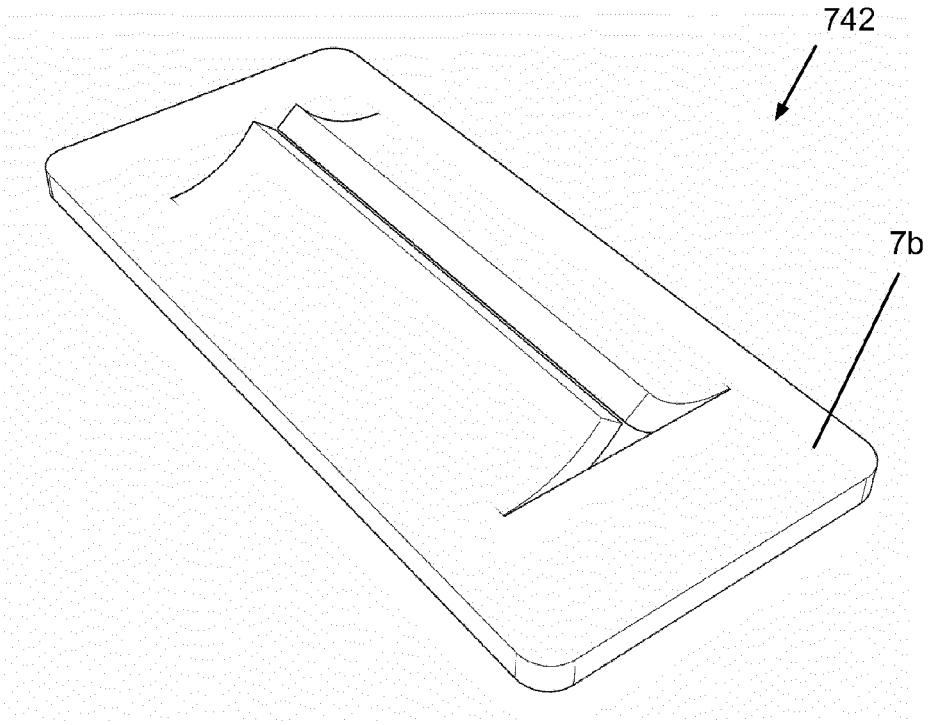

Fig. 11

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EUROPEAN SEARCH REPORT

Application Number
EP 19 20 6614

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	US 3 898 987 A (ELAM JAMES O) 12 August 1975 (1975-08-12) * column 1 - column 5; figures * -----	1-7	INV. A63B21/00 A63B23/18 A63B21/062
Y	US 4 025 070 A (MCGILL LEE E ET AL) 24 May 1977 (1977-05-24) * column 2 - column 4; figures * -----	1-7	
Y	US 4 138 105 A (HUNGER DARRELL M ET AL) 6 February 1979 (1979-02-06) * column 3 - column 4; figures * -----	1-7	
Y	US 4 114 607 A (RUSSO RONALD D) 19 September 1978 (1978-09-19) * figures * -----	1-7	
Y	US 2014/150801 A1 (RUSHER MICHAEL J [US]) 5 June 2014 (2014-06-05) * paragraph [0133] - paragraph [0169]; figures * -----	1-7	
			TECHNICAL FIELDS SEARCHED (IPC) A63B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	19 December 2019	Borrás González, E

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 20 6614

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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19-12-2019

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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