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(54) Benævnelse: **LYDDÆMPER TIL VARMEGENVINDINGSVENTILATIONSENHED**

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DESCRIPTION

[0001] The present invention relates to a silencer for a heat recovery ventilation unit (HRV). A HRV unit provides supply air, preferably outside air or fresh air, to an apartment or parts thereof and removes return air, preferably exhaust air or used air, from said apartment or parts thereof.

[0002] A silencer in accordance with the preamble of claim 1 is known from EP 2 642 215 A1.

[0003] Heat recovery ventilation units have been used for many years in ventilation systems to recover heat from exhaust air exiting a house or an apartment to the surrounding atmosphere. A heat exchanger is used to transfer heat from the exhaust air exiting the house or the apartment to the outside air entering the house or the apartment. Such ventilation systems comprise an arrangement of ducts for transporting air between selected rooms of an apartment (or house) and the surrounding atmosphere. More precisely, such heat recovery ventilation systems comprise ducts collecting return air (used air) from the rooms, ducts for distributing supply air (fresh air) to the rooms on the one hand, and ducts for transporting exhaust air from the apartment to the atmosphere and ducts for transporting outside air from the atmosphere to the apartment. A heat recovery ventilation unit is located at a crossing point at which the ducts of these four air types meet. Consequently, such heat recovery ventilation units typically comprise some passive elements such as a supply air outlet, a return air inlet, an exhaust air outlet, an outside air inlet and a heat exchanger inside the unit, as well as some active elements such as a first ventilator (fan) at a first location within the ventilation unit, for transporting air through a first air flow path starting at the return air inlet, passing through first air flow passages in the heat exchanger and ending at the exhaust air outlet, and a second ventilator (fan) at a second location within the ventilation unit, for transporting air through a second air flow path starting at the outside air inlet, passing through second air flow passages and ending at the supply air outlet.

[0004] In operation, with air flows passing through these elements of a HRV unit, all of these elements, as a function of their geometric design and/or their mode of operation, contribute to a higher or lesser degree to the overall noise generation of the HRV unit. Typically, such noise results from air flow noise in the ducts and from rotating ventilator blades in the unit. Such noise may be quite annoying to the persons living in the HRV unit equipped apartment and reduces the overall benefit and acceptance of heat recovery ventilation.

[0005] In order to reduce the noise level within the HRV unit equipped apartment, it is common practice to install silencers at some of the above-mentioned air inlets and outlets. However, it has turned out to be impossible to achieve a close to total elimination of such noise with reasonably sized silencers.

[0006] It is an object of the invention to provide a silencer for a HRV unit which, on the one hand, is reasonably sized and which, on the other hand, still provides a significant absorption of all kinds of noise originating in the HRV unit.

[0007] This object is achieved by a silencer unit, according to claim 1.

[0008] According to the invention, the silencer unit comprises separate silencer ducts to be connected to said supply air outlet, return air inlet, exhaust air outlet and outside air inlet, respectively, of the heat recovery ventilation unit.

[0009] The silencer unit according to the invention provides a silencer duct for each of the air inlets and air outlets of the corresponding HRV unit. As a result, a significant reduction of the noise originating from the HRV unit in operation can be achieved.

[0010] Preferably, the silencer unit with all its silencer ducts is formed as a one-piece element from a sound-absorbing material. Such sound absorbing material may be a foamed polymer material such as a foamed thermoplastic material, or it may be a foamed elastomeric material. The one-piece silencer unit may be formed in a one-step foaming process within a mold.

[0011] In a preferred embodiment of the invention, one or two of the four air inlets and air outlets of the HRV unit have a shape differing from the shape of the other air inlets and air outlets of the HRV unit, and the silencer ducts of the silencer unit have duct ends corresponding in shape to the shapes of the air inlets and air outlets of the HRV unit. Thus, there is only one position of the silencer unit with respect to the HRV unit that allows the silencer unit to be connected to the HRV unit. As a result, there is no risk for the silencer unit to be connected in a wrong way to the HRV unit.

[0012] In a further preferred embodiment, the air inlets and air outlets of the HRV unit are located on one side, preferably the upper side, of the HRV unit substantially in a planar arrangement within a plane defined by said one side of the HRV unit, said planar arrangement of air inlets and air outlets being rotationally asymmetric with respect to rotation of said arrangement around an axis of rotation normal to said plane, and wherein the silencer ducts of the silencer unit have duct ends arranged in a substantially planar arrangement corresponding to the planar arrangement of the air inlets and air outlets of the HRV unit. Again, there is only one position of the silencer unit with respect to the HRV unit that allows the silencer unit to be connected to the HRV unit. As a result, there is no risk for the silencer unit to be connected in a wrong way to the HRV unit.

[0013] All silencer ducts of the silencer unit may be straight ducts. A silencer unit with only straight ducts can be easily manufactured.

[0014] In a further preferred embodiment, the silencer duct for the supply air outlet of the HRV unit and the silencer duct for the return air inlet of the HRV unit are curved ducts each comprising at least one bend. Curving the ducts increases their sound absorption capacity but also their resistance against air flow through the ducts. As most of the ventilation related noise in the apartment or parts thereof originates from the supply air outlet of the HRV unit and from the return air inlet of the HRV unit, providing extra sound absorption for these two openings of the HRV unit at the expense of more air flow resistance is very effective. The silencer ducts for the exhaust air outlet and the outside air inlet of the HRV unit may be straight ducts having less sound absorption but also less air flow resistance. This is a good trade-off between maximizing overall sound absorption and minimizing additional air flow resistance due to the silencer unit.

[0015] Preferably, the silencer duct for the supply air outlet of the HRV unit and the silencer duct for the return air inlet of the HRV unit are curved ducts each comprising a first bend and a second bend arranged in series, with the first bend being curved in a first direction and the second bend being curved in a second direction. This S-shaped duct provides very good sound absorption to the air inlet or air outlet of the HRV unit to which it is connected. Preferably, the S-shaped silencer duct does not have any abrupt changes in curvature along its duct length, i.e. the derivative of the S-shaped curve does not have any discontinuities.

[0016] Preferably, the first bend is curved in a first direction and the second bend is curved in a second direction opposite to the first direction. This provides increased sound absorption due to the bends while still maintaining a substantially straight overall silencer duct geometry.

[0017] According to the invention, the silencer ducts to be connected to the supply air outlet and the return air inlet of the HRV unit have a rectangular cross section along their entire duct length. Alternatively, the silencer ducts to be connected to the supply air outlet and the return air inlet of the HRV unit have a rectangular cross section along their duct length and a circular cross section at their duct ends to be connected to the HRV unit, with a step free rectangular-to circular cross section transition region extending between the region of rectangular cross section and the region of circular cross section.

[0018] Preferably, the sound absorbing material includes a fire-retardant and/or a biocidal coating. The sound absorbing material may be a foamed material with open or closed pores. The inner silencer duct walls may be coated or covered with a smooth hygienic coating.

[0019] Preferably, at least one, and preferably all, of the silencer ducts comprise a first shaped part and a second shaped part arranged in spaced relationship with respect to each other to form the respective silencer duct between the first shaped part and the second shaped part.

[0020] Preferably, the first shaped part and the second shaped part are identical in shape.

[0021] Preferably, the shaped parts are made from a porous open cell material such as foamed melamine resin, wherein the first shaped part has a first duct delimiting surface and the shaped part has a second duct delimiting surface facing the first duct delimiting surface.

[0022] In a preferred embodiment, the duct delimiting surface of each of the shaped parts has a longitudinal profile P(x) extending between an upstream duct end x_{in} and a downstream duct end x_{out} of a silencer duct, said longitudinal profile P(x) having consecutive profile sections of varying slope dP/dx with respect to a straight reference line extending between a center point of the upstream duct end x_{in} and a center point of the downstream duct end x_{out}.

[0023] These profile sections are defined by:

a first profile section having a substantially constant positive slope of 25 to 45°, preferably 28 to 42°;

a second profile section substantially defined by a convex arc section varying in slope between a maximum positive slope of 25 to 45°, preferably 28 to 42°, and a minimum negative slope of 15 to 35°, preferably 18 to 32°;

a third profile section having a substantially constant negative slope of 15 to 35°, preferably 18 to 32°;

a fourth profile section substantially defined by a concave arc section varying in slope between a minimum negative slope of 15 to 35°, preferably 18 to 32°, and a maximum positive slope of 15 to 35°, preferably 18 to 32°;

a fifth profile section substantially defined by a convex arc section varying in slope between a maximum positive slope of 15 to 35°, preferably 18 to 32°, and a minimum negative slope of 12 to 22°, preferably 15 to 20°; and

a sixth profile section having a substantially constant negative slope of 12 to 22°, preferably 15 to 20°.

[0024] Preferably, the first profile section has a first sub-section and a second sub-section downstream of the first sub-section, where the positive slope of the second sub-section is smaller than the positive slope of the first subsection.

[0025] Preferably, an intermediate profile section is provided between the fourth profile section and the fifth profile section, whit the intermediate profile having a positive slope of 15 to 35°, preferably 18 to 32°.

Brief description of the drawings

[0026]

Fig. 1 is a perspective view of an embodiment of the silencer unit according to the invention.

Fig. 2 is a top view of the silencer unit of Fig. 1.

Fig. 3 is a front view of the silencer unit of Fig. 1.

Fig. 4 is a cross section along plane A-A of Fig. 3.

Fig. 5 is a cross section along plane D-D of Fig. 2.

Fig. 6 is a cross section along plane F-F of Fig. 2.

Fig. 7 is a perspective view of two identical shaped parts used in the silencer unit of the invention.

Fig. 1 is a perspective view of an embodiment of the silencer unit 1 showing a silencer ducts 2, 4, 6, 8 to be connected to a supply air outlet, return air inlet, exhaust air outlet and outside air inlet, respectively, of a heat recovery ventilation unit (not shown).

Fig. 2 is a top view of the silencer unit 1 again showing the silencer ducts 2, 4, 6, 8.

Fig. 3 is a front view of the silencer unit 1 again showing the silencer ducts 2, 6, 8 and the duct ends 2a, 6a, 8a. The silencer duct 4 and the duct end 4a are hidden behind the silencer duct 2 and the duct end 2a.

Fig. 4 is a cross section along plane A-A of Fig. 3 showing rectangular duct cross sections 2R and 4R of silencer ducts 2 and 4, respectively, and circular duct cross sections 6C and 8C of silencer ducts 6 and 8, respectively.

Fig. 5 is a cross section along plane D-D of Fig. 2 showing silencer ducts 6 and 8 with circular cross sections 6C and 8C, respectively, and duct ends 6a and 8a, respectively.

Fig. 6 is a cross section along plane F-F of Fig. 2 showing silencer duct 2 having a first bend 2b and a second bend 2c arranged in series, with the first bend 2b being curved in a first direction and the second bend 2c being curved in a second direction opposite to the first direction. Fig. 6 also shows the silencer duct 2 with a rectangular cross section 2R along its duct length and a circular cross section 2C at its duct end 2a to be connected to the HRV unit, and with a step free rectangular-to-circular cross section transition region 2RC extending between the region of rectangular cross section and the region of circular cross section. Again, the silencer duct 4 and the duct end 4a are hidden behind the silencer duct 2 and the duct end 2a. Silencer duct 4 has a shape identical to silencer duct 2 and is arranged next to silencer duct 2.

[0027] The curved silencer duct 2 is curved such that a straight line extending from a first point within the first silencer duct opening 2a to a second point within the second silencer duct opening 2d cannot be fitted into the curved silencer duct 2. This guarantees that any sound wave originating from within the HRV unit (not shown) and entering the curved silencer duct 2 of the silencer unit 1 at whatever angle will not pass straight through the silencer duct 2. Rather, it will impinge on one of the silencer duct walls and be scattered and absorbed by the sound absorbing material.

[0028] The curved silencer duct 2 comprising at least one bend 2b, 2c is composed of a first shaped part 10 and a second shaped part 10 which, when placed next to each other, constitute said curved silencer duct 2 therebetween. Thus, even complicated silencer duct geometries which may not be easily manufactured by a single molding process, are possible with pairs of identical shaped parts 10.

[0029] As best seen in Figs. 4, 5 and 6, the silencer unit 1 has a cavity 12, 14 for receiving and locating said first shaped part 10 and said second shaped part 10 next to each other. This modular approach increases accuracy of the silencer ducts 2, 4 assembled in this manner and also helps simplify the overall manufacturing steps and reduce manufacturing cost.

[0030] Fig. 7 is a perspective view of a shaped part 10 and an identically shaped part 10' made of melamine resin used in the silencer unit 1 of the invention. A duct delimiting surface 11, 12 of each of the shaped parts 10, 10' has a longitudinal profile P(x) extending between an upstream duct end x_{in} and a downstream duct end x_{out} of a silencer duct 2, 4, 6, 8. The longitudinal profile P(x) has consecutive profile sections Pa, Pb, Pc, Pd, Pe, Pf of varying slope dP/dx with respect to a straight reference line extending between a center point of the upstream duct end x_{in} and a center point of the downstream duct end x_{out}. The profile sections are defined by:

a first profile section Pa having a substantially constant positive slope of 28 to 42°, the first profile section Pa having a first sub-section Pa1 and a second sub-section Pa2 downstream of the first sub-section Pa1, with the positive slope of the second sub-section Pa2 being smaller than the positive slope of the first subsection Pa1; a second profile section Pb substantially defined by a convex arc section varying in slope between a maximum positive slope of 28 to 42° and a minimum negative slope 18 to 32°;

a third profile section Pc having a substantially constant negative slope of 18 to 32°; a fourth profile section Pd substantially defined by a concave arc section varying in slope between a minimum negative slope of 18 to 32° and a maximum positive slope of 18 to 32°;

a fifth profile section Pe substantially defined by a convex arc section varying in slope between a maximum positive slope of 18 to 32° and a minimum negative slope of 15 to 20°; and

a sixth profile section Pf having a substantially constant negative slope of 15 to 20°, an intermediate profile section Pde being provided between the fourth profile section Pd and the fifth profile section Pe, the intermediate profile Pde having a positive slope of 18 to 32°.

[0031] In a silencer duct 2, 4, 6, 8 of the silencer unit 1 of the invention, the second shaped part 10' is turned by 180° and in close relationship with the first shaped part 10 such that the duct delimiting surface 11 of the first shaped part 10 and the duct delimiting surface of the second shaped part 10' face each other, thus defining the a duct 2, 4, 6, 8 therebetween.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP2642215A1 [0002]

LYDDÆMPER TIL VARMEGENVINDINGSVENTILATIONSENHED

Patentkrav

1. Lyddæmperenhed (1) til en varmegenvindingsventilations-(HRV)-enhed til tilvejebringelse af forsyningsluft, fortrinsvis udeluft (frisk luft), til en lejlighed eller dele deraf og til fjernelse af returluft, fortrinsvis afgangsluft (anvendt luft), fra lejligheden eller delene deraf,
hvilken varmegenvindingsventilationsenhed omfatter:
en forsyningsluftudgang til etablering af forsyningsluftgennemstrømningsforbindelse med lejligheden;
en returluftindgang til etablering af returluftgennemstrømningsforbindelse med lejligheden;
en afgangsluftudgang til etablering af afgangsluftgennemstrømningsforbindelse med atmosfæren;
en udeluftindgang til etablering af udeluftgennemstrømningsforbindelse med atmosfæren,
hvor lyddæmperenheden (1) skal forbindes med luftindgange og luftudgange i varmegenvindingsventilationsenheden, hvilken lyddæmperenhed er kendetegnet ved, at lyddæmperenheden (1) omfatter separate lyddæmperkanaler (2, 4, 6, 8), der skal forbindes med henholdsvis forsyningsluftudgangen, returluftindgangen, afgangsluftudgangen og udeluftindgangen i varmegenvindingsventilationsenheden,
kendetegnet ved, at lyddæmperkanalerne (2, 4), der skal forbindes med forsyningsluftudgangen og returluftluftindgangen på HRV-enheden, har et rektangulært tværsnit (2R, 4R) langs hele deres kanallængde.

2. Lyddæmperenhed ifølge krav 1, hvor lyddæmperenheden med alle dens lyddæmperkanaler er dannet som et element i ét stykke af lyddæmpende materiale.

3. Lyddæmperenhed ifølge krav 2, hvor en eller to af de fire luftindgange og luftudgange i HRV-enheden har en form, der afviger fra formen af de andre luftindgange og luftudgange på HRV-enheden, og hvor lyddæmperkanalerne i lyddæmperenheden har kanalender, der i form svarer til formen af luftindgangene og luftudgangene på HRV-enheden.

4. Lyddæmperenhed ifølge krav 2 eller 3, hvor luftindgangene og luftudgangene på HRV-enheden er placeret på den ene side, fortrinsvis oversiden, af HRV-enheden i det væsentlige i et planarrangement i et plan, der er defineret af samme ene side af HRV-enheden, hvilket planarrangement af luftindgange og luftudgange er rotationsasymmetrisk med hensyn til rotation af arrangementet omkring en rotationsakse, der er normal i forhold til planet, og hvor lyddæmperkanalerne (2, 4, 6, 8) i lyddæmperenheden (1) har kanalender (2a, 4a, 6a, 8a), som er anbragt i et i alt væsentligt planarrangement, der svarer til planarrangementet af luftindgangene og luftudgangene på HRV-enheden.lyddæmperkanaler er retlinede kanaler.

5. Lyddæmperenhed ifølge et af kravene 1 til 4, hvor alle lyddæmperkanaler er lige kanaler.

6. Lyddæmperenhed ifølge et af kravene 1 til 4, hvor lyddæmperkanalen (2) til forsyningsluftudgangen i HRV-enheden og lyddæmperkanalen (4) til returluftindgangen i HRV-enheden er krumme kanaler (2, 4), der hver især omfatter mindst én bøjning (2b, 4b).

7. Lyddæmperenhed ifølge krav 6, hvor lyddæmperkanalen (2) til forsyningsluftudgangen i HRV-enheden og lyddæmperkanalen (4) til returluftindgangen i HRV-enheden er buede kanaler, som hver omfatter en første bøjning (2b, 4b) og en anden bøjning (2c, 4c) anbragt på række, hvor den første bøjning (2b, 4b) er buet i en første retning og det andet buk (2c, 4c) er buet i en anden retning.

8. Lyddæmperenhed ifølge krav 7, hvor den første bøjning (2b, 4b) er buet i en første retning, og den anden bøjning (2c, 4c) er buet i en anden retning modsat den første første retning.med hele kanallængden.

9. Lyddæmperenhed ifølge et af kravene 1 til 8, hvor lyddæmperkanalerne (2, 4), som skal forbindes med forsyningsluftudgangen og returluftindgangen i HRV-enheden, har et cirkulært tværsnit (2C, 4C) ved deres ender (2a, 4a), der skal forbindes med HRV-enheden, hvor en trinløs rektangulær-til-cirkulær tværsnitsovergangsregion (2RC, 4RC) strækker sig mellem regionen i det rektangulære tværsnit og regionen i det cirkulære tværsnit.

10. Lyddæmperenhed ifølge et af kravene 8 eller 9, hvor mindst én af, og fortrinsvis alle, lyddæmperkanalerne (2, 4, 6, 8) omfatter en første formet del (10) og en anden formet del (10), som er anbragt med indbyrdes mellemrum til dannelse af den pågældende lyddæmperkanal (2, 4, 6, 8) mellem den første formede del (10) og den anden formede del (10).

11. Lyddæmperenhed ifølge krav 10, hvor den første formede del (10) og den anden formede del (10) er identiske i form, og/eller hvor de formede dele (10, 10') er fremstillet af porøst åbent cellemateriale, og den første formede del (10) har en første kanalafgrænsende overflade (11), og den formede del (10') har en anden kanalafgrænsende overflade (12), som vender mod den første kanalafgrænsende overflade (11).

12. Lyddæmperenhed ifølge krav 11, hvor den kanalafgrænsende overflade (11, 12) af hver af de formede dele (10, 10') har en længdeprofil P(x), som strækker sig mellem en opstrøms kanalende (x_{ind}) og en nedstrøms kanalende (x_{ud}) af en lyddæmperkanal (2, 4, 6, 8), hvor længdeprofilen P(x) har på hinanden følgende profilafsnit (Pa, Pb, Pc, Pd, Pe, Pf) med varierende hældning dP/dx i forhold til en lige referencelinje, der strækker sig mellem et midtpunkt af den opstrøms kanalende (x_{ind}) og et midtpunkt af den nedstrøms kanalende (x_{ud}), hvor profilafsnittene er defineret ved:
et første profilafsnit (Pa) med en i det væsentlige konstant positiv hældning på 25 til 45°, fortrinsvis 28 til 42°;
et andet profilafsnit (Pb), der i det væsentlige er defineret ved et konvekst bueafsnit, hvis hældning varierer mellem en maksimal positiv hældning på 25 til 45°, fortrinsvis 28 til 42°, og en minimal negativ hældning på 15 til 35°, fortrinsvis 18 til 32°;
et tredje profilafsnit (Pc) med en i det væsentlige konstant negativ hældning på 15 til 35°, fortrinsvis 18 til 32°;
et fjerde profilafsnit (Pd), der i det væsentlige er defineret ved et konkavt bueafsnit, hvis hældning varierer mellem en minimal negativ hældning på 15 til 35°, fortrinsvis 18 til 32°, og en maksimal positiv hældning på 15 til 35°, fortrinsvis 18 til 32°;
et femte profilafsnit (Pe), der i det væsentlige er defineret ved et konvekst bueafsnit, hvis hældning varierer mellem en maksimal positiv hældning på 15 til 35°, fortrinsvis 18 til 32°, og en minimal negativ hældning på 12 til 22°, fortrinsvis 15 til 20°; og
et sjette profilafsnit (Pf) med en i det væsentlige konstant negativ hældning på 12 til 22°, fortrinsvis 15 til 20°.

13. Lyddæmperenhed ifølge krav 12, hvor det første profilafsnit (Pa) har et første underafsnit (Pa1) og et andet underafsnit (Pa2) nedstrøms i forhold til det første underafsnit (Pa1), hvor den positive hældning af det andet underafsnit (Pa2) er mindre end den positive hældning af det første underafsnit (Pa1).

14. Lyddæmperenhed ifølge krav 12 eller 13, hvor der er anbragt et mellemprofilafsnit (Pde) mellem det fjerde profilafsnit (Pd) og det femte profilafsnit (Pe), hvor mellemprofilen (Pde) har en positiv hældning på 15 til 35°, fortrinsvis 18 til 32°.

DRAWINGS

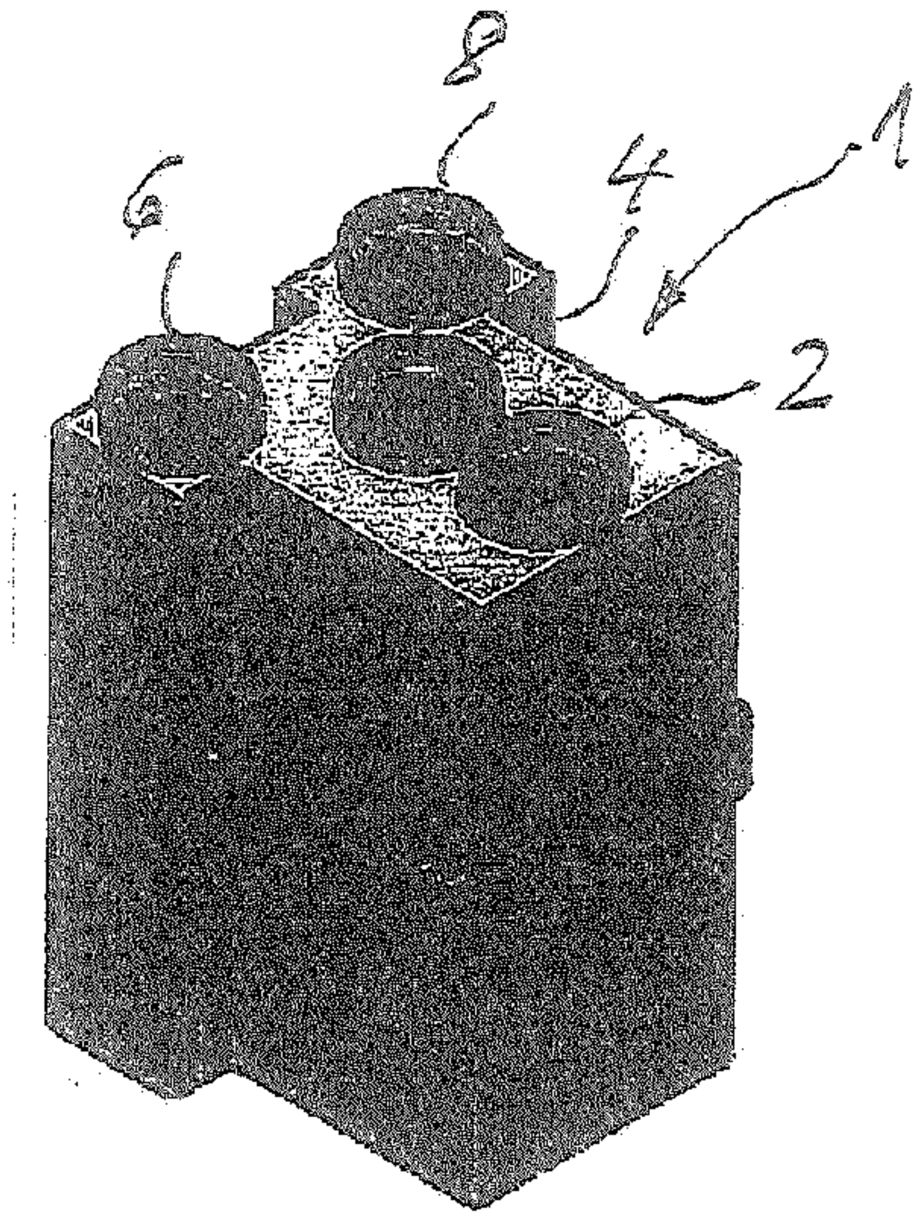

Fig. 1

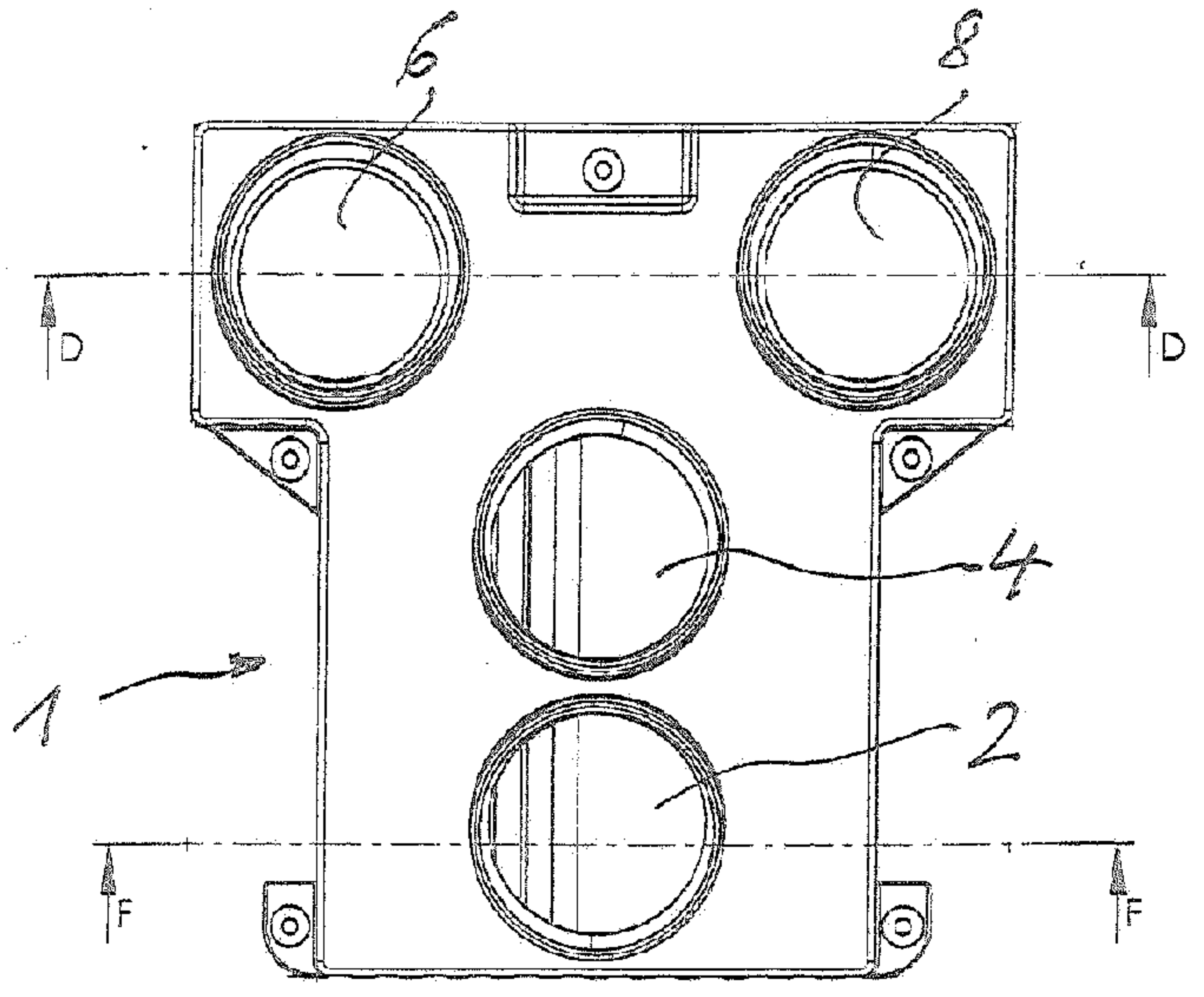

Fig. 2

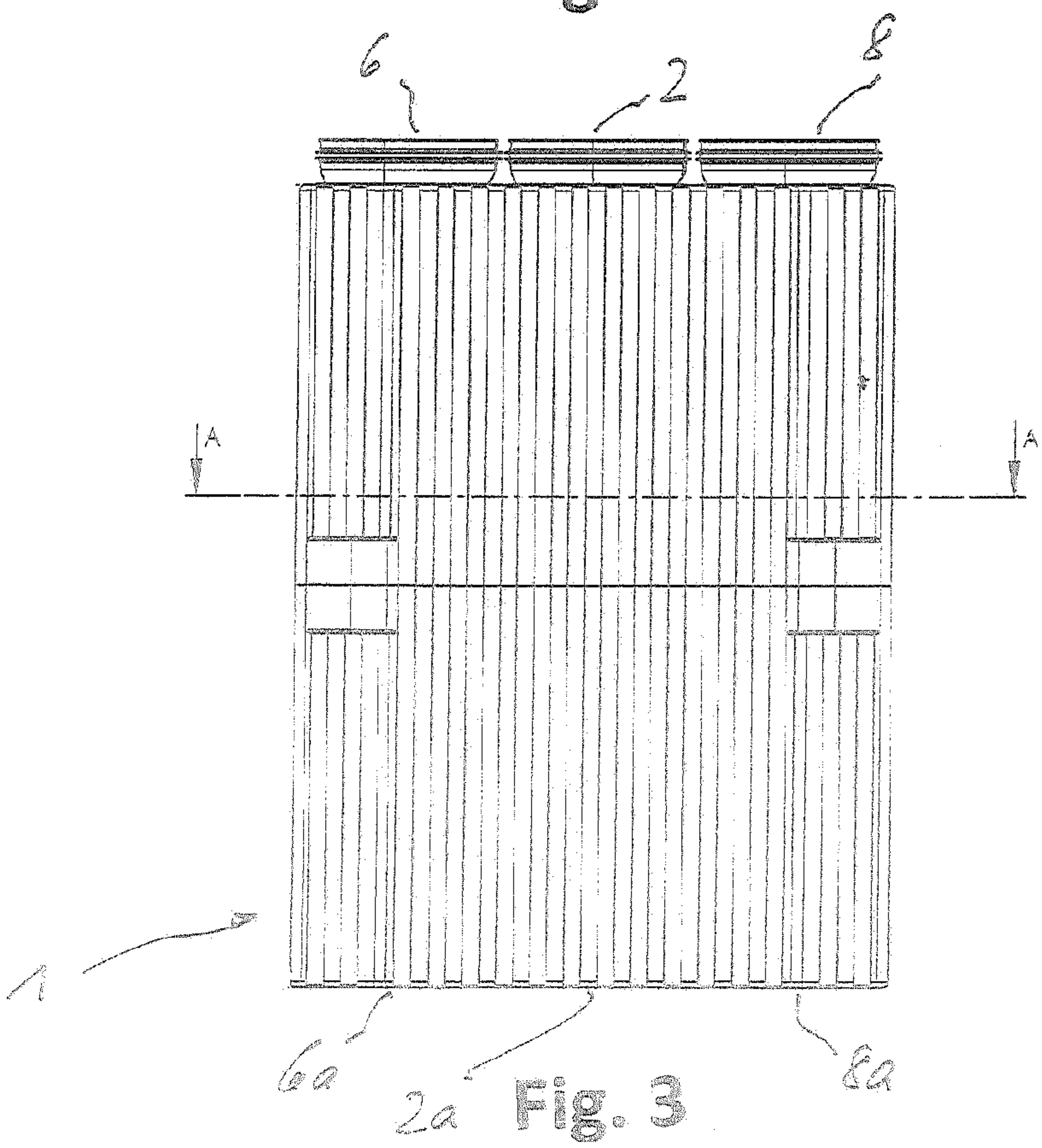

Fig. 3

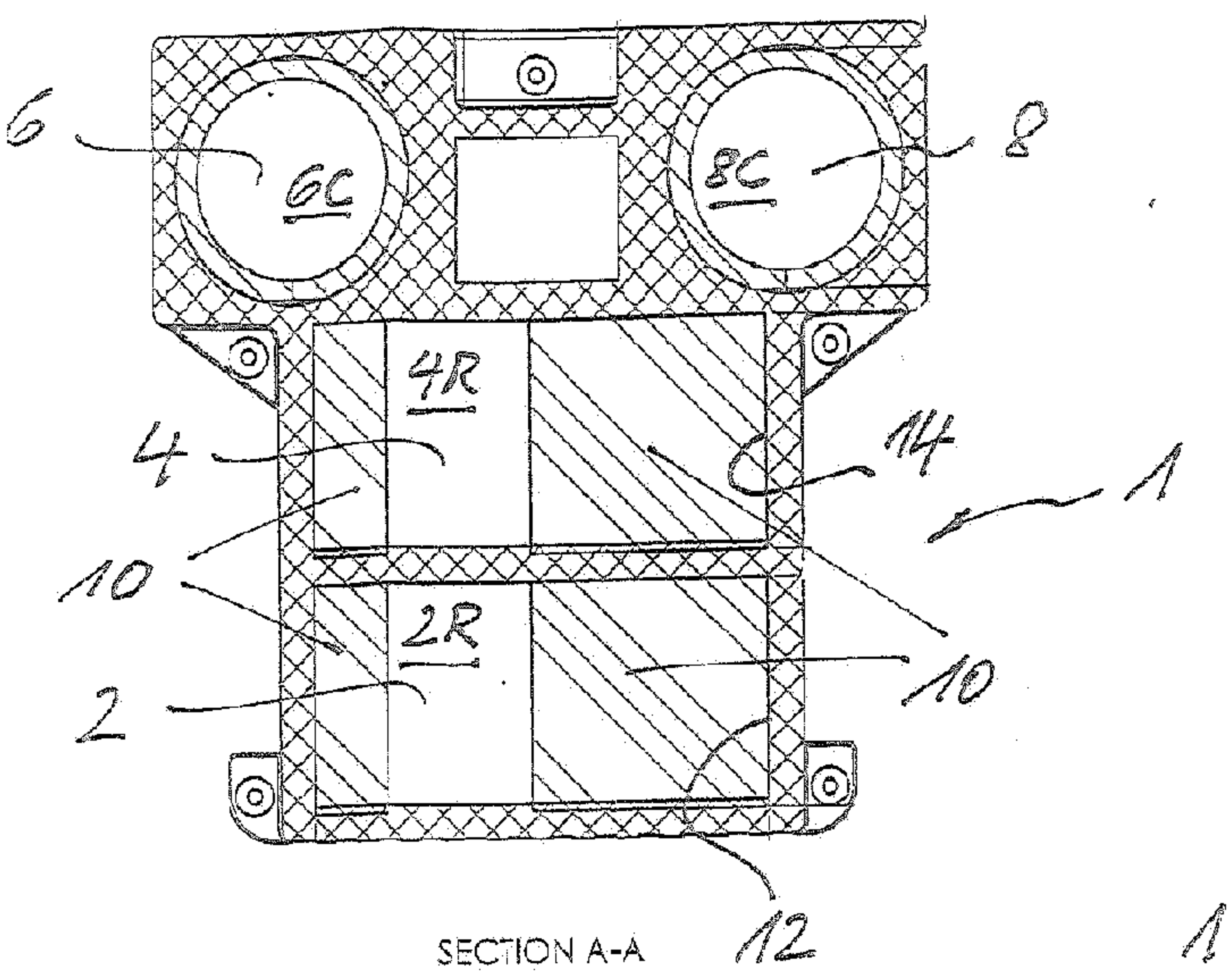

Fig. 4

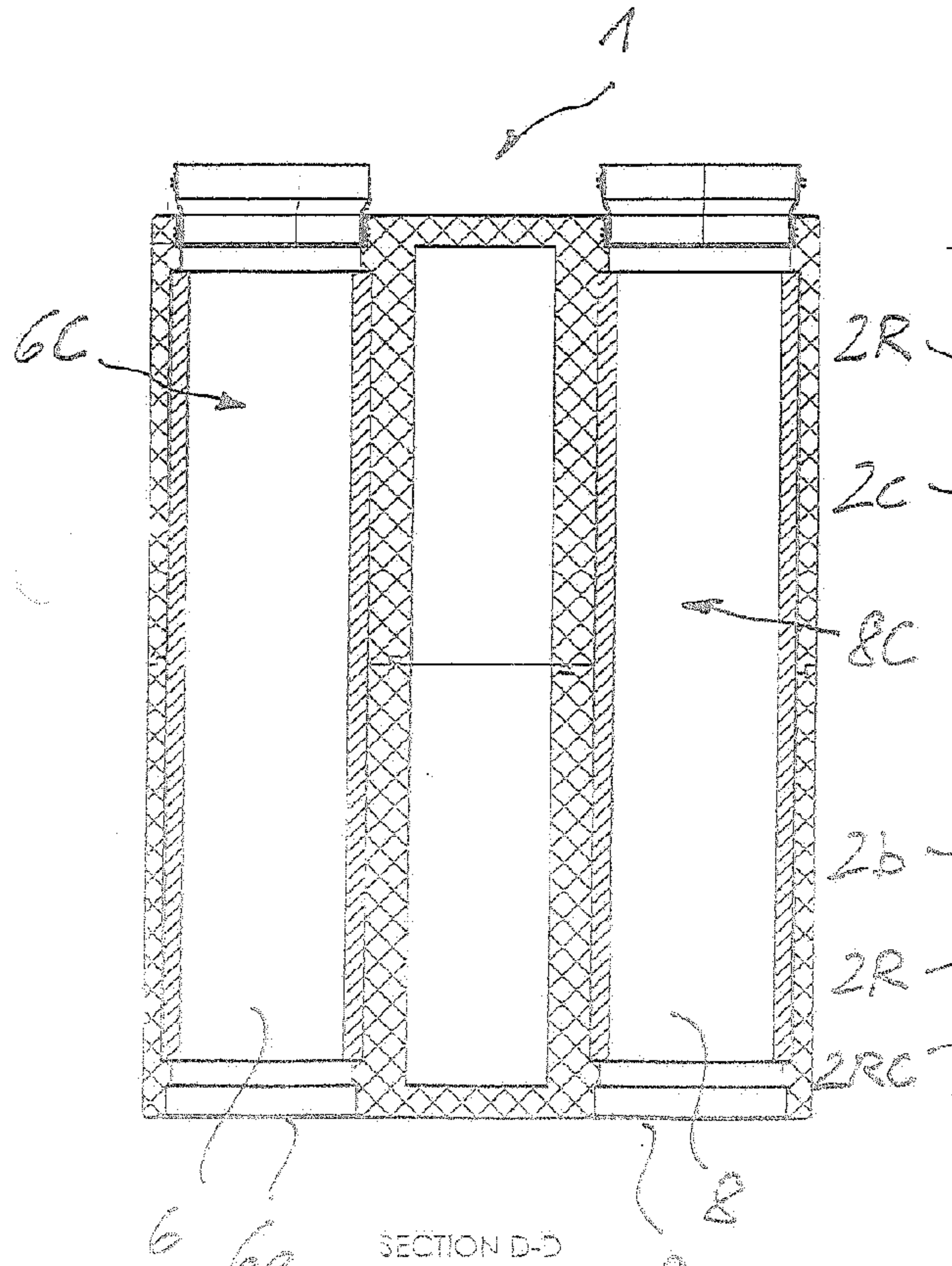

Fig. 5

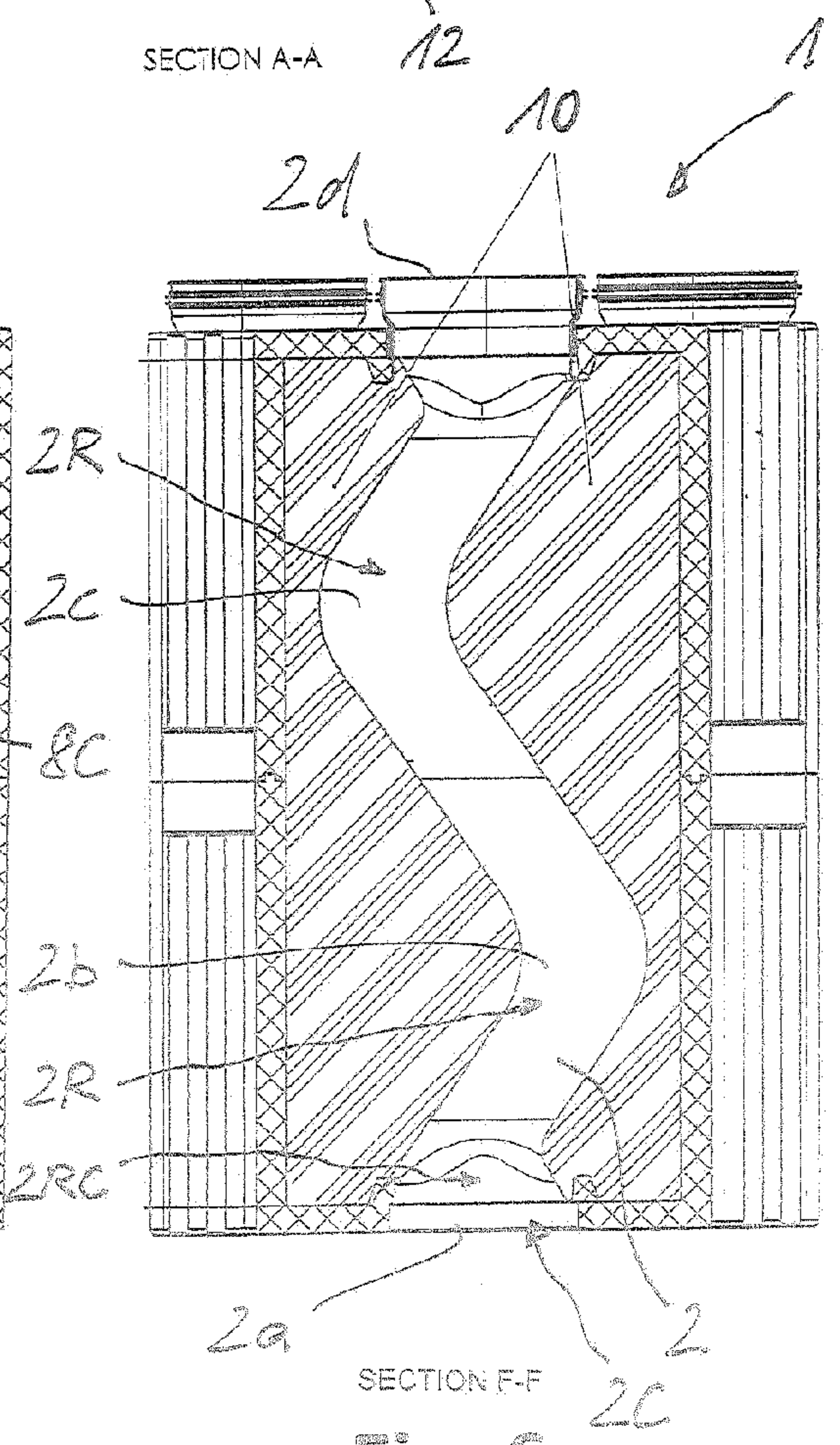

Fig. 6

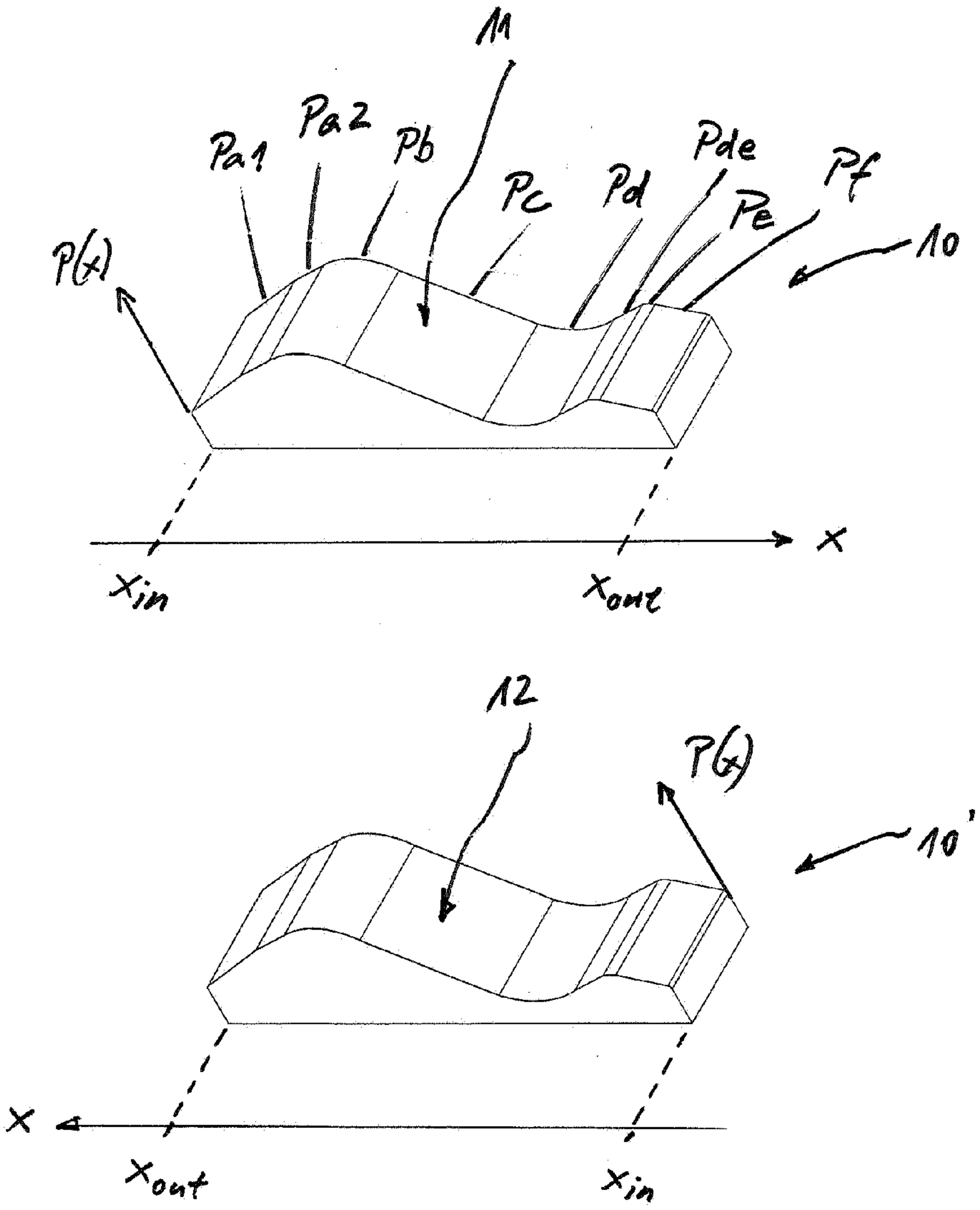

Fig. 7