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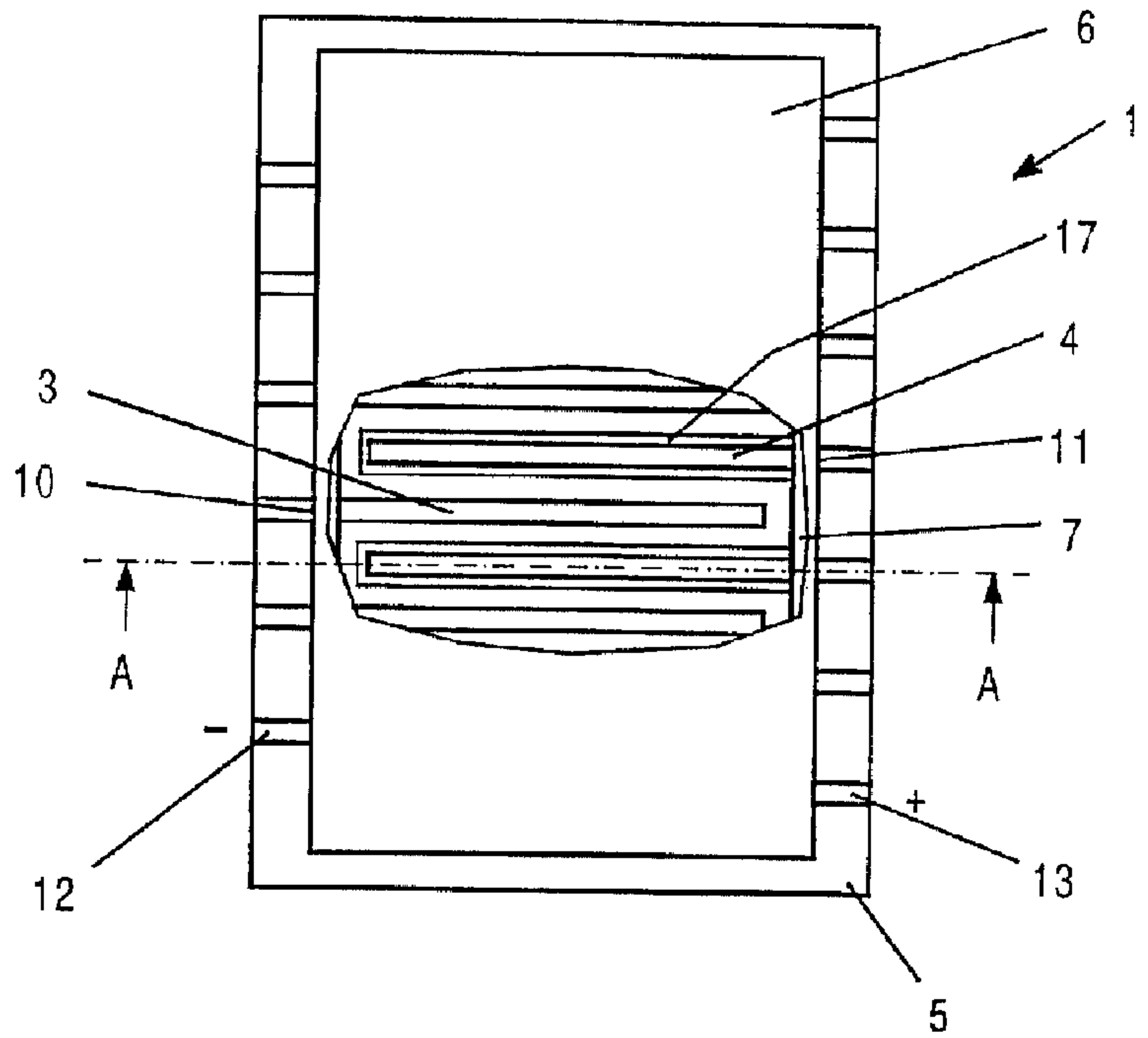
(72) Inventeurs/Inventors:
VOLLKOMMER, FRANK, DE;
HITZSCHKE, LOTHAR, DE

(73) Propriétaire/Owner:
PATENT-TREUHAND-GESELLSCHAFT FUER ELEKTRISCHE GLUEHLAMPEN MBH, DE

(74) Agent: SMART & BIGGAR

(54) Titre : SPOT PLAT A DECHARGE SEPAREE PAR UNE COUCHE DIELECTRIQUE ET DISPOSITIF DESTINE AU PASSAGE DES ELECTRODES DANS L'ESPACE DE DECHARGE

(54) Title: FLAT SPOTLIGHT WITH DISCHARGE SEPARATED BY A DIELECTRIC LAYER AND DEVICE FOR THE ELECTRODES INTO THE LEADING DISCHARGE AREA



(57) Abrégé/Abstract:
A flat radiator (1) with a closed discharge vessel (2) filled with a gas filling has dielectrically impeded, strip-like electrodes in the interior. The discharge vessel (2) comprises at least one base plate (5) and one top plate (6), which are interconnected in a gas-tight fashion by means of solder (8), if appropriate also via an additional frame (7) arranged between the top plate and base plate. The strip-like internal electrodes (3; 4) additionally merge into feedthroughs (10, 11), and the latter in turn merge into external supply leads (12; 13) in such a way that the internal electrodes (3, 4), the feedthroughs (10, 11) and the external supply leads (12; 13) are constructed as in each case functionally different sections of cathode-side or anode-side structures (3, 10, 12; 4, 11, 13) resembling conductor tracks. At least the anodes (4) are covered in each case with a dielectric layer (17). The feedthroughs (10, 11) are, if appropriate, additionally covered in a gas-tight fashion by the solder (8). Fig. 1a.

ABSTRACT

A flat radiator (1) with a closed discharge vessel (2) filled with a gas filling has dielectrically impeded, strip-like electrodes in the interior. The discharge vessel (2) comprises at least one base plate (5) and one top plate (6), which are interconnected in a gas-tight fashion by means of solder (8), if appropriate also via an additional frame (7) arranged between the top plate and base plate. The strip-like internal electrodes (3; 4) additionally merge into feedthroughs (10, 11), and the latter in turn merge into external supply leads (12; 13) in such a way that the internal electrodes (3, 4), the feedthroughs (10, 11) and the external supply leads (12; 13) are constructed as in each case functionally different sections of cathode-side or anode-side structures (3, 10, 12; 4, 11, 13) resembling conductor tracks. At least the anodes (4) are covered in each case with a dielectric layer (17). The feedthroughs (10, 11) are, if appropriate, additionally covered in a gas-tight fashion by the solder (8). Fig. 1a.

Technical field

The invention relates to the field of flat radiators.

The designation "flat radiator" is understood here to mean radiators having a flat geometry and which emit light, that is to say visible electromagnetic radiation, or else ultraviolet (UV) or vacuum ultraviolet (VUV) radiation.

Depending on the spectrum of the emitted radiation, such radiation sources are suitable for general and auxiliary lighting, for example home and office lighting or background lighting of displays, for example LCDs (Liquid Crystal Displays), for traffic lighting and signal lighting, for UV irradiation, for example sterilization or photolysis.

At issue here are flat radiators which are operated by means of dielectrically impeded discharge.

In this type of radiator, either the electrodes of one polarity or all the electrodes, that is to say of both polarities, are separated from the discharge by means of a dielectric layer (discharge dielectrically impeded at one end or two ends, see WO 94/23442 or EPO 363 382, for example). Such electrodes are also designated as "dielectric electrodes" below for short.

The dielectric layer can be formed by the wall of the discharge vessel itself by arranging the electrodes outside the discharge vessel, for example on the outer wall. An advantage of this design with external electrodes is that there is no need to lead gas-tight electrical feedthroughs through the wall of the discharge vessel. However, the thickness of the dielectric layer - an important parameter which, inter alia, influences the starting voltage and the operating voltage of the discharge - is essentially fixed by the requirements placed on the discharge vessel, in particular the mechanical strength of the latter. Since the level of the required supply voltage increases with the thickness of the dielectric layer, the following disadvantages arise, inter alia. First and foremost, the power supply provided for operating the flat radiator must be designed for the higher voltage requirement. As a rule, this is attended by additional costs and larger external dimensions. Moreover, more stringent safety arrangements are required for shock protection.

On the other hand, the dielectric layer can also be realized in the shape of an at least partial covering or coating of at least one electrode arranged inside the discharge vessel. This has the advantage that the thickness of the dielectric layer can be optimized with regard to the discharge characteristics. However, internal electrodes require gas-tight electrical feedthroughs. Additional production steps are thereby required, and this generally increases the cost of production.

Usually, elongated electrodes of differing polarity (anodes and cathodes) are arranged alternately next to one another, it thereby being possible to realize planar-like discharge configurations with relatively flat discharge vessels. Likewise, the anodes and cathodes can be arranged on different sides of the inner wall of the discharge vessel, for example in such a way that in each case an anode and cathode are opposite one another. Moreover, the electrodes are connected in pairs to the two terminals of a voltage source. A particularly efficient method of operating radiators with dielectric electrodes is described in WO 94/23442.

Prior art

DE-A 195 26 211 discloses a flat radiator which is operated with the aid of a sequence of effective power pulses separated from one another by pauses - that is to say, in accordance with the operating method of WO 94/23442. In the exemplary embodiments, strip-shaped electrodes, inter alia, are arranged on the outer wall of the discharge vessel.

EP 0 363 832 discloses, inter alia, a UV high-power radiator having strip-shaped electrodes which are arranged inter alia on the inner wall of the discharge vessel. However, there are no data concerning the electrical feedthroughs for connecting the internal electrodes to a voltage source.

Normally, the internal electrodes of discharge lamps and discharge radiators are connected to a supply lead in the form of a wire or like a foil. A feedthrough connects the supply lead in the interior of the discharge vessel to external supply leads which, for their part, serve to connect to an electric supply source. In order to ensure gas-tightness, it is, on the one hand, necessary for the feedthrough to be closely surrounded by the material of the discharge vessel. On the other hand, the materials of the feedthrough, usually a metal or a metal alloy, and the discharge vessel, for example glass or ceramic, have partially very different coefficients of thermal expansion. In order to avoid high mechanical stresses and consequently fractures and cracks due to stress in the feedthrough region, the feedthroughs are realized, inter alia, by means of very thin wires. However, this technique is limited to low current intensities or lamp powers, since the thin wires would otherwise burn through in a fashion similar to a fuse. It is known to remedy this disadvantage by using a thin foil, for example a molybdenum foil with a thickness of approximately 10-20 µm, in the sealing region of the feedthrough.

Because of the many individual parts and of steps in manipulation and production, the said techniques are little suited to automated production of flat radiators having very many electrode strips.

Representation of the invention

According to one aspect of the invention, there is provided a flat radiator having an at least partially transparent discharge vessel which is closed and filled with a gas filling and consists of electrically non-conducting material, and having strip-like electrodes comprising anodes and cathodes, the electrodes arranged on the inner wall of the discharge vessel, at least the anodes being covered in each case with a dielectric layer, wherein the discharge vessel has at least one base plate and one top plate, the base plate and the top plate being interconnected in a gas-tight fashion by means of solder, the strip-like internal electrodes additionally merge into feedthroughs, and the feedthroughs in turn merge into external supply leads in such a way that the electrodes, the feedthroughs and the external supply leads are constructed as in each case functionally differing subregions of structures resembling conductor tracks, the feedthroughs being guided outwards, covered in a gas-tight fashion through the solder, and the external supply leads immediately adjacent thereto serving to connect an electric supply source.

In embodiments of the invention, the flat radiator has electrical feedthroughs in such a way that the flat radiator - largely independently of the size and thus of the number of electrodes - can be produced in relatively few production steps and thus cost- effectively.

The term "strip-like electrode" or "electrode strip" for short is to be understood here and below as an elongated structure which is very thin by comparison with its length and is capable of acting as an electrode. The edges of this structure need not necessarily be parallel to one another in this case. In particular, substructures along the longitudinal sides of the strips are also to be included.

The invention proposes to develop the internal strip-like electrodes themselves additionally as feedthroughs including external supply leads.

For this purpose, the discharge vessel is constructed from a base plate and a top plate which are interconnected by means of solder, for example glass solder - possibly, but not necessarily, via an additional frame.

A frame can be dispensed with if at least one of the two plates is, for example, shaped like a trough in such a way that a discharge space is enclosed by the base plate and top plate.

The electrode strips are in each case guided outwards in a gas-tight fashion with one end through the solder. The strips themselves are applied directly in a gas-tight fashion to the base plate and/or top plate - in a fashion similar to conductor tracks on an electric printed circuit board -, for example by vapour deposition, silk-screen printing with subsequent burning in, or similar techniques. The sealing of the feedthrough and of the other components is undertaken by the solder.

In this way, the internal electrodes, the feedthroughs and external supply leads are, as it were, simultaneously produced in a common production step as functionally differing subregions of an in each case single cathode-side or anode-side layer-like conductor track structure. By contrast with the prior art, the number of steps of manipulation and production is thereby greatly reduced. A further advantage of the invention is that it permits the cost-effective production of flat radiators of virtually any size, since the said production section can always be realized in the same way virtually independently of the size of the radiator.

In a first simple design, outside the discharge vessel the electrode strips can terminate after the feedthrought region in a number of external supply leads corresponding to the number of electrode strips. Thus, seen per se, each electrode strip is constructed as a structure resembling a conductor track which in each case comprises the three following, functionally differing subregions: internal electrode region, feedthrough region and external supply lead region.

This embodiment takes account of the circumstance that the mutual connection of the supply leads of the same polarity for the connection to the two poles of a voltage source can also be performed inside a suitable connecting device connected between the flat radiator and voltage source, for example a specially adapted plug/cable combination.

In a second design, the electrode strips of the same polarity merge into in each case a common, bus-like external supply lead. During operation, these two external supply leads are connected to one pole each of a voltage source. The advantage by comparison with the first design is that it is possible to dispense with a specifically adapted plug/cable combination.

In order to keep mechanical stresses due to different thermal expansions low, and to ensure gas-tightness even during continuous operation, the materials for the glass solder and frame as well as the base plate and top plate are tailored to one another. Moreover, the thicknesses of the conductor tracks (electrode, feedthrough, supply lead) are selected to be so thin that, on the one hand, the thermal stresses remain low and that, on the other hand, the current intensities required during operation can be realized.

In this case, a sufficiently high current carrying capacity of the conductor tracks requires a particular importance since the high luminous intensities aimed at for such flat radiators finally require high current intensities. Particularly in the case of flat fluorescent lamps for background lighting of liquid crystal displays (LCD), a particularly high luminous intensity is mandatory because of the low transmission of such displays of typically 6%. This problem is further heightened in the case of the preferred pulsed mode of operation of the discharge, since particularly high currents flow in the conductor tracks during the relatively short duration of the repetitive injection of effective power. It is only in this way that it is also possible to inject sufficiently high average effective powers and thereby to achieve the desired high luminous intensity on average over time.

Relatively thick conductor tracks are used in order to ensure the abovementioned high current carrying capacity. Specifically, excessively low conductor track thicknesses run the risk of the formation of cracks because of local overheating of the conductor tracks. The heating of the conductor tracks by the ohmic component of the conductor track current is the greater the smaller the cross-section of the conductor tracks. The width of the conductor tracks is, however, subject to limits, inter alia because with increasing width there is likewise an increase in the shading of the luminous area of the flat radiator by the conductor tracks. Consequently, the aim is rather conductor tracks which are narrow, but for this reason as thick as possible, in order to solve the problem of the formation of cracks because of the development of heat by high current densities in the conductor tracks. Typical thicknesses for conductive silver strips are in the region of approximately 5 μm to approximately 50 μm, preferably in the region of approximately 5.5 μm to approximately 30 μm, particularly preferably in the region of approximately 6 μm to approximately 15 μm.

However, with conductor tracks of such thicknesses on relatively extended flat substrate materials such as are used in flat radiators, formation of cracks is to be expected due to material stresses which result, for example, from the bending loads upon evacuation during the production process. The reason for the growing risk of the formation of cracks is the functional dependence of the yield point ε of a layer on the thickness d thereof in accordance with $\varepsilon \propto 1/\sqrt{d}$. In accordance therewith, the yield point is the smaller the greater the layer thickness. Moreover, with increasing layer thickness the probability of discontinuities inside the layer rises dramatically. These discontinuities lead to locally increased tensile stresses inside the layer. This leads, finally, to the risk that the layer will peel off from the substrate material.

It has proved, surprisingly, that flat radiators can nevertheless be produced in a gastight fashion with conductor tracks of such thicknesses, and that, moreover, the service life can by all means amount to a few thousand hours.

It is possible that a contribution is also made to this by support points specifically arranged at a suitable spacing from one another between the base plate and top plate, for example in the form of glass balls which lend the flat radiator sufficient bending stability without causing unacceptably strong shading.

According to the current state of knowledge, the two parameters $P_1=d_{Sp}\cdot d_{E1}$ and $P_2=d_{Sp}/d_{P1}$, inter alia, are regarded as relevant for the service life of the flat radiator, d_{Sp} being the spacing of the support points from one another or from the delimiting side wall, d_{E1} denoting the thickness of the electrode tracks, and d_{P1} denoting the smaller of the two thicknesses of the base plate or top plate. Typical values for P_1 are in the region of 50 mm µm to 680 mm µm, preferably in the region of 100 mm µm to 500 mm µm, particularly preferably of 200 mm µm to 400 mm µm. Typical values for P_2 are in the region of 8 to 20, preferably in the region of 9 to 18, particularly preferably in the region of 10 to 15.

Good results were achieved, for example, with 10 µm thick printed silver layers and glass balls fitted by means of glass solder between in each case 2.5 mm thick base plate and top plate at a mutual spacing of approximately 34 mm. These values result in P_1=340 mm µm and P_2=13.6.

Also disclosed is an irradiation system which comprises the above mentioned novel flat radiator and a pulsed voltage source.

Accordingly in another aspect of the invention, there is provided a radiation system having a flat radiator and an electric pulsed voltage source which is suitable for supplying during operation voltage pulses separated by pauses from one another, characterized in that the flat radiator has features of the previous aspect, the pulsed voltage source being connected to the external supply leads of the flat radiator in an electrically conductive fashion.

Description of the drawings

The invention is to be explained below in more detail with the aid of two exemplary embodiments. In the drawings:

Figure 1a shows a first exemplary embodiment of a flat radiator in a partly cut away top view,

Figure 1b shows a cross-section through the flat radiator of Figure 1a along the line AA,

Figure 2a shows a second exemplary embodiment of a flat radiator in a partly cut away top view,
Figure 2b shows a cross-section through the flat radiator from Figure 2a along the line AA, and

Figure 2c shows a representation of a detail of a cross-section through the flat radiator of Figure 2b along the line BB.

Figures 1a and 1b diagrammatically show a flat radiator 1 in top view, and a sectional representation along the line AA. The flat radiator 1 comprises a discharge vessel 2, strip-shaped cathodes 3 and dielectrically impeded, strip-shaped anodes 4.

The discharge vessel 2 comprises a base plate 5, a top plate 6 and a frame 7, which all have a rectangular base face. The base plate 5 and top plate 6 are connected in a gas-tight fashion to the frame by means of glass solder 8 in such a way that the interior 9 of the discharge vessel 2 is of cuboid construction. The wall thickness of the base plate and top plate, which consist of glass, is in each case approximately 2.5 mm. The frame is made from a glass tube with a diameter of approximately 5 mm. Fitted between the base plate and top plate are precision glass balls with a diameter of 5 mm as support points, this being done equidistantly at a mutual spacing of approximately 34 mm by means of glass solder (not represented, for the sake of clarity). The base plate 5 is larger than the top plate 6 in such a way that the discharge vessel 2 has a free-standing circumferential edge.

The cathodes 3 and anodes 4 are arranged alternately and parallel to one another at a mutual spacing of approximately 6 mm on the inner wall of the base plate 5. The cathodes 3 and anodes 4 are extended at mutually opposite ends and are guided outwards on both sides as cathode-side 10 or anode-side 11 feedthroughs from the interior 9 of the discharge vessel 2 on the base plate 5. On the edge of the base plate 5, the feedthroughs 10; 11 in each case merge into cathode-side 12 or anode-side 13 external supply leads. The external supply leads serve as external contacts for the connection to preferably one electric pulsed voltage source (not represented), if appropriate by means of suitable plug-in connectors (not represented).

Applied to the inner wall of the top plate 6 is a layer 16 of a mixture of fluorescent materials, which converts the predominantly shortwave radiation of the discharge into visible white light. This is a three-band fluorescent material having the blue component BAM ($BaMgAl_{10}O_{17}$: Eu^{2+}), the green component LAP ($LaPO_4$: [Tb^{3+}, Ce^{3+}]) and the red component YOB ([Y, Gd] BO_3: EU^{3+}). The layer thickness is approximately 27 µm. In a preferred variant (not represented), apart from the inner wall of the top plate, the inner wall of the base plate including the electrodes as well as the frame are additionally coated with a mixture of fluorescent materials. Furthermore, one light-reflecting layer each made from TiO_2 and Al_2O_3 is applied directly to the inner wall of the base plate. The layer thicknesses are approximately 15 µm or 7 µm respectively.

This variant is not represented for the reason that the fluorescent layer would block the view onto the electrode strips.

The cut-out in the top plate 6 serves solely representational aims and exposes the view onto part of the anodes 4 and cathodes 3. In the interior 9 of the discharge vessel 2, the anodes 4 are completely covered by a glass layer 17 (compare also Figure 1b, which shows a section of the flat radiator 1 along an anode 4), whose thickness is approximately 250 µm. The electrodes 3; 4, feedthroughs 10; 11, and external supply leads 12; 13 are realized as functionally different sections of a cathode-side and an anode-side continuous layer structure made from silver, which are applied together by means of the silk-screen printing technique and subsequent burning in. The layer thickness is approximately 10 µm.

The flat radiator 1′ represented in Figures 2a-2c diagrammatically in top view and as a section along the lines AA and BB, respectively, differs from the flat radiator 1 (Figures 1a and 1b) only in the shaping of the external supply lead 12; 13. The feedthroughs 10; 11 of each electrode strip 3; 4 are firstly extended on the edge of the base plate 5 and end in a cathode-side 12 or anode-side 13 bus-like conductor track. Finally, these conductor tracks 12; 13 end in two neighbouring sections 14; 15. The two sections 14; 15 serve as external contacts for the connection to an electric voltage source (not represented).

Figure 2c represents only a section, enlarged by comparison with Figure 2b, along the line BB, so as to render the relationships clearer.

In a further variant (not represented), the cathode strips are applied to the inner wall of the top plate. Each cathode strip is assigned an anode strip pair in such a way that, seen in cross-section, in each case the imaginary connection between cathodes and corresponding anodes gives rise to the shape of a "V" standing on its head. Cathode strips and anode strips are guided outwards on the same side of the fluorescent lamp by means of feedthroughs, and merge on the corresponding edge of the top or bottom plate into the cathode-side or anode-side supply lead, respectively. Both the anode strips and the cathode strips are completely covered with a dielectric layer which extends over the complete inner wall of the base plate and of the top plate in such a way that the dielectric layer additionally serves as glass solder for the gas-tight connection. A light-reflecting layer made from TiO_2 and Al_2O_3 is applied in each case to the dielectric layer of the base plate. Following as last layer thereupon, and likewise on the dielectric layer of the top plate is a layer of fluorescent materials made from a mixture of BAM, LAP and YOB.

The invention is not restricted by the specified exemplary embodiments. It is also possible in addition, to combine features of different exemplary embodiments.

CLAIMS:

1. A flat radiator having an at least partially transparent discharge vessel which is closed and filled with a gas filling and consists of electrically non-conducting material, and having strip-like electrodes comprising anodes and cathodes, the electrodes arranged on the inner wall of the discharge vessel, at least the anodes being covered in each case with a dielectric layer, wherein

the discharge vessel has at least one base plate and one top plate, the base plate and the top plate being interconnected in a gas-tight fashion by means of solder,

the strip-like internal electrodes additionally merge into feedthroughs, and the feedthroughs in turn merge into external supply leads in such a way that the electrodes, the feedthroughs and the external supply leads are constructed as in each case functionally differing subregions of structures resembling conductor tracks,

the feedthroughs being guided outwards, covered in a gas-tight fashion through the solder, and the external supply leads immediately adjacent thereto serving to connect an electric supply source.

2. The flat radiator according to claim 1, wherein the base plate and the top plate are also interconnected via an additional frame arranged between the top plate and the base plate.

3. The flat radiator according to claim 1 or 2, wherein the dielectric layers serve additionally as solder for the gas-tight feedthroughs.

4. The flat radiator according to any one of claims 1 to 3, wherein the external supply leads are arranged on the outer wall of the discharge vessel.

5. The flat radiator according to any one of claims 1 to 4, wherein a cathode-side structure and an anode-side structure each comprise a metal layer, the layer thickness being between 5 μm and 50 μm.

6. The flat radiator according to claim 5, wherein the layer thickness is 5.5 μm to 30 μm.

7. The flat radiator according to claim 5, wherein the layer thickness is 6 μm to 15 μm.

8. The flat radiator according to claim 4, wherein the layer thickness is approximately 10 μm.

9. The flat radiator according to any one of claims 1 to 8, wherein spacers are arranged between the base plate and the top plate.

10. The flat radiator according to claim 9, wherein the spacers are realized by glass balls.

11. The flat radiator according to claim 9 or 10, wherein a parameter $P_1=d_{Sp}\cdot d_{E1}$ is from 50 mm μm to 680 mm μm, d_{Sp} denoting the spacing of the support points from one another or from the delimiting side wall, and d_{E1} denoting the thickness of the electrode tracks.

12. The flat radiator according to claim 11, wherein the parameter P_1 is from 100 mm μm to 500 mm μm.

13. The flat radiator according to claim 11, wherein the parameter P_1 is from 200 mm μm to 400 mm μm.

14. The flat radiator according to any one of claims 9 to 13, wherein a parameter $P_2=d_{Sp}/d_{P1}$ is from 8 to 20, d_{Sp} denoting the spacing of the support points from one another or from the delimiting side wall, and d_{P1} denoting the smaller of the two thicknesses of base plate or top plate.

15. The flat radiator according to claim 14, wherein the parameter P_2 is from 9 to 18.

16. The flat radiator according to claim 14, wherein the parameter P_2 is from 10 to 15.

17. The flat radiator according to claim 1 or 2, wherein the coefficient of thermal expansion of the solder is tailored to the coefficients of thermal expansion of the materials of the base plate and of the top plate.

18. The flat radiator according to claim 1 or 2, wherein at least a part of the inner wall of the discharge vessel has a layer made from a fluorescent material or mixture of fluorescent materials.

19. The flat radiator according to claim 18, wherein a light-reflecting layer is applied to a part of the inner wall of the discharge vessel, in particular to the inner wall of the base plate, between the inner wall and layer of fluorescent materials.

20. The flat radiator according to any one of claims 1 to 19, wherein the external supply leads being constructed in such a way that the feedthroughs of the cathodes and the anodes open into a cathode-side or anode-side bus-like conductor track.

21. The flat radiator according to claim 20, the bus-like conductor track being arranged on the outer wall of the discharge vessel.

22. A radiation system having a flat radiator and an electric pulsed voltage source which is suitable for supplying during operation voltage pulses separated by pauses from one another, characterized in that the flat radiator has features of any one of claims 1 to 13, the pulsed voltage source being connected to the external supply leads of the flat radiator in an electrically conductive fashion.

SMART & BIGGAR
OTTAWA, CANADA

PATENT AGENTS

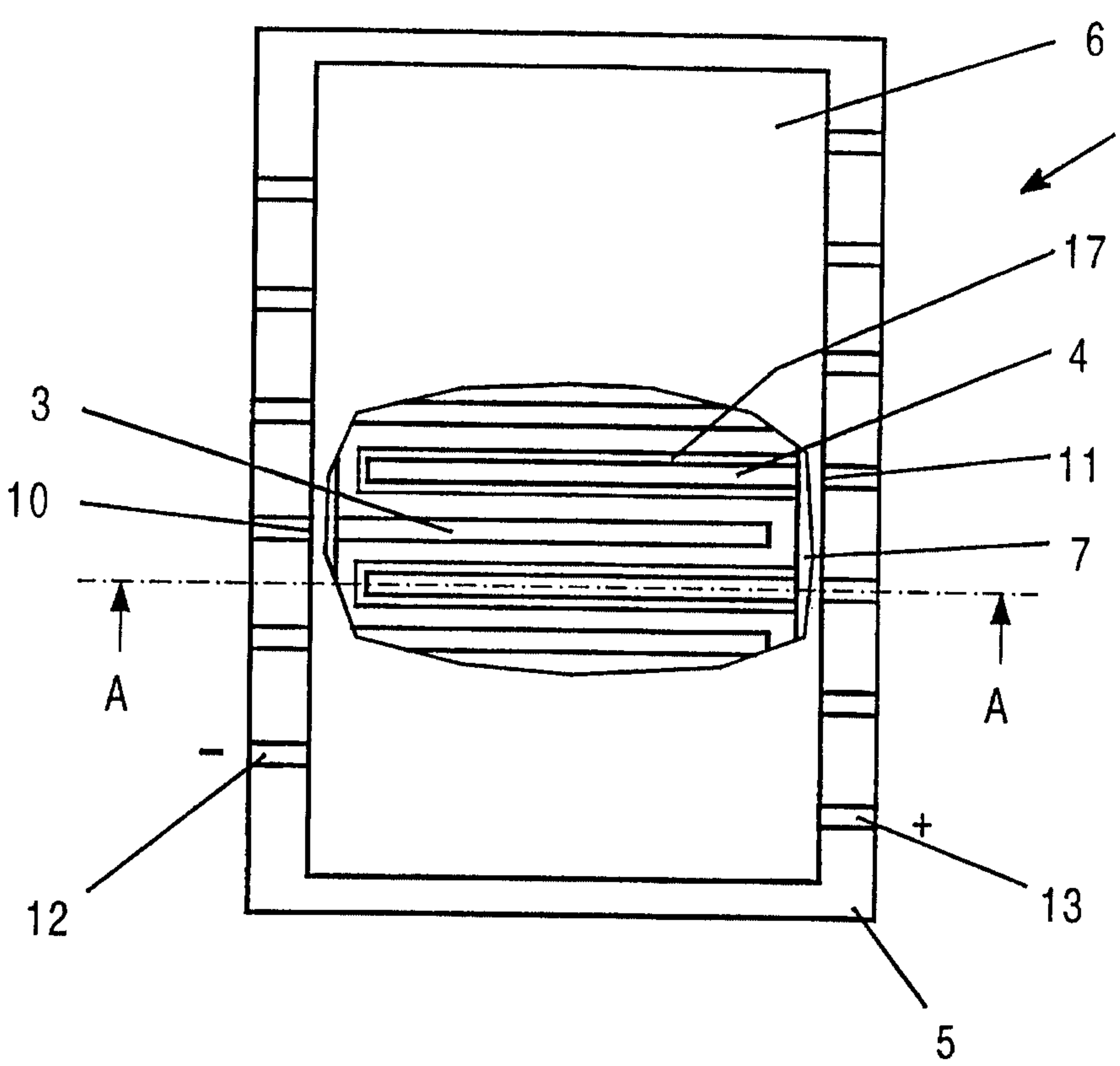


FIG. 1a

AA

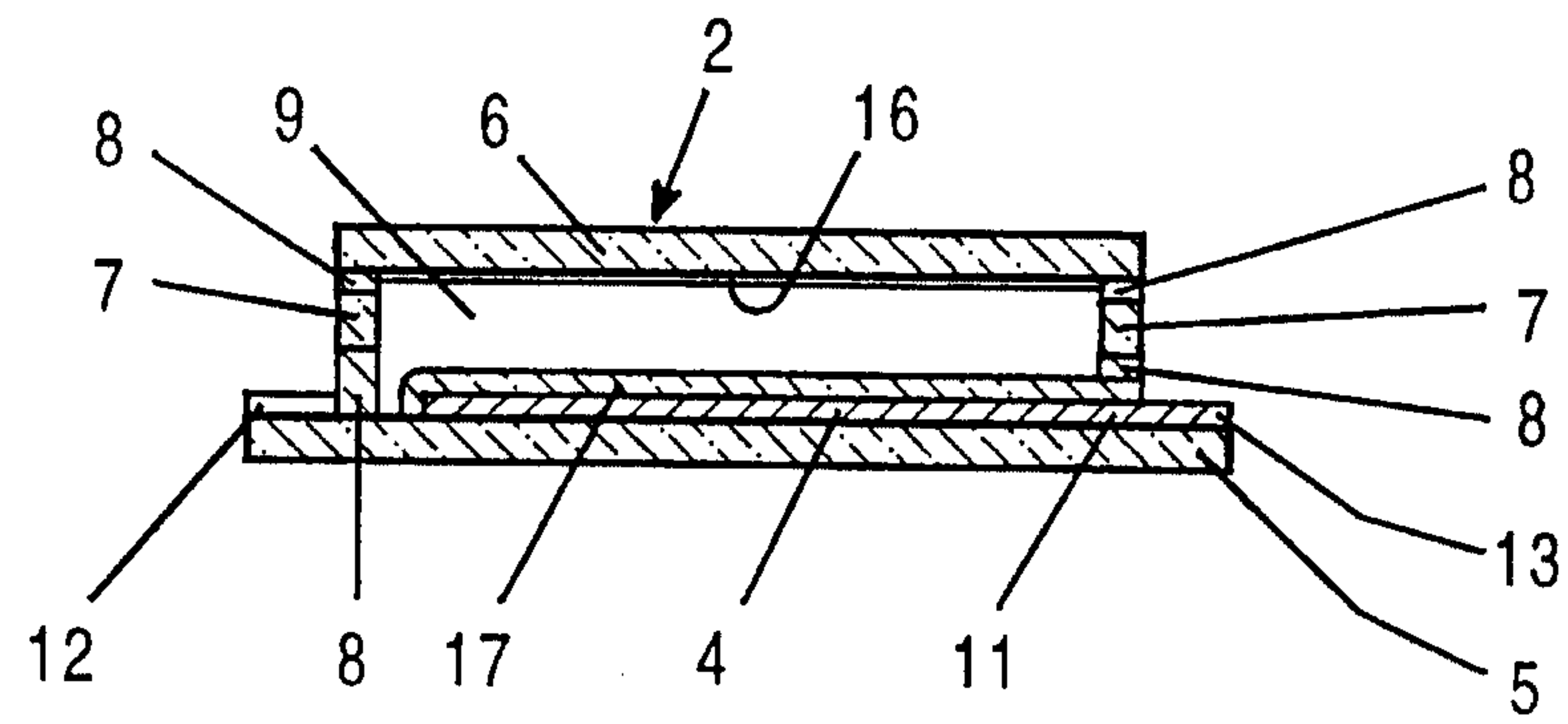


FIG. 1b

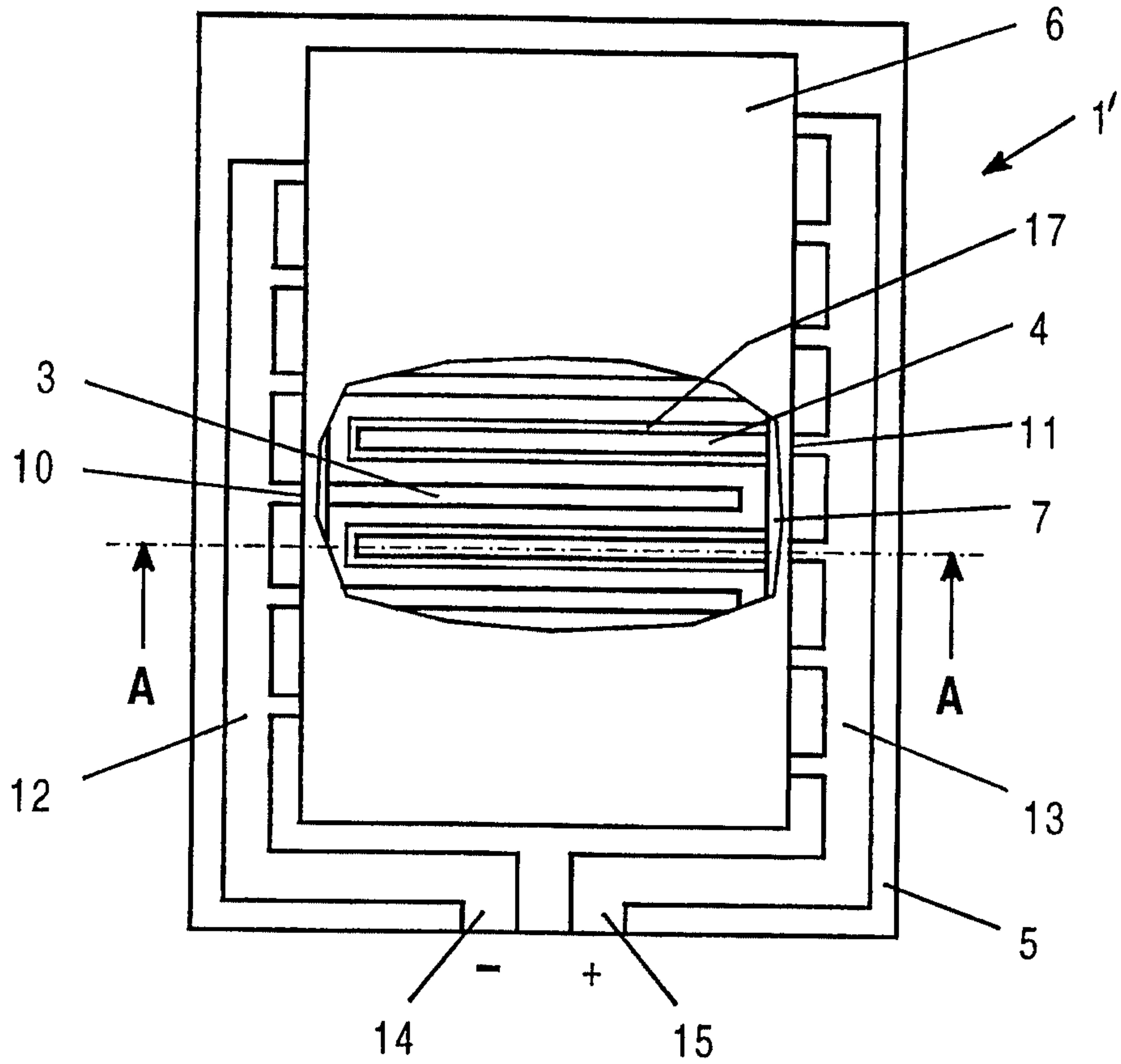


FIG.2a

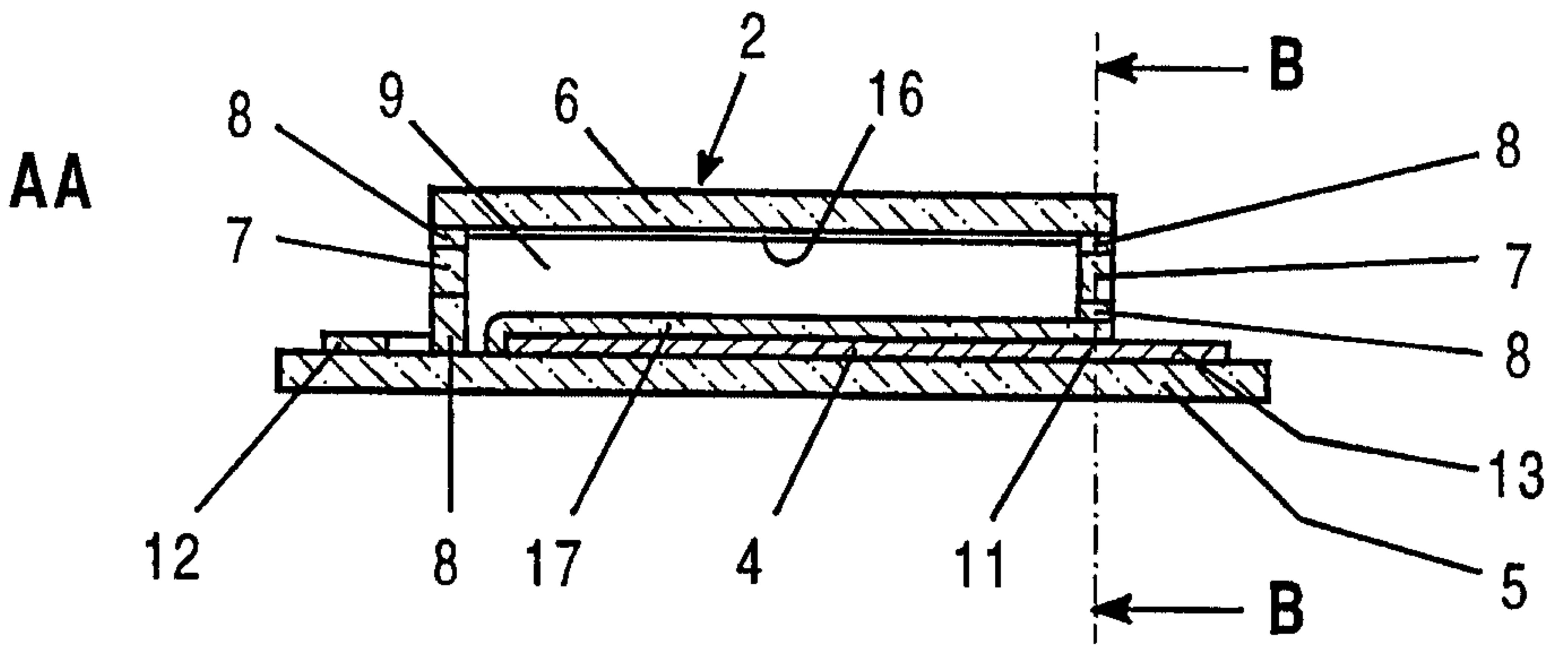


FIG. 2b

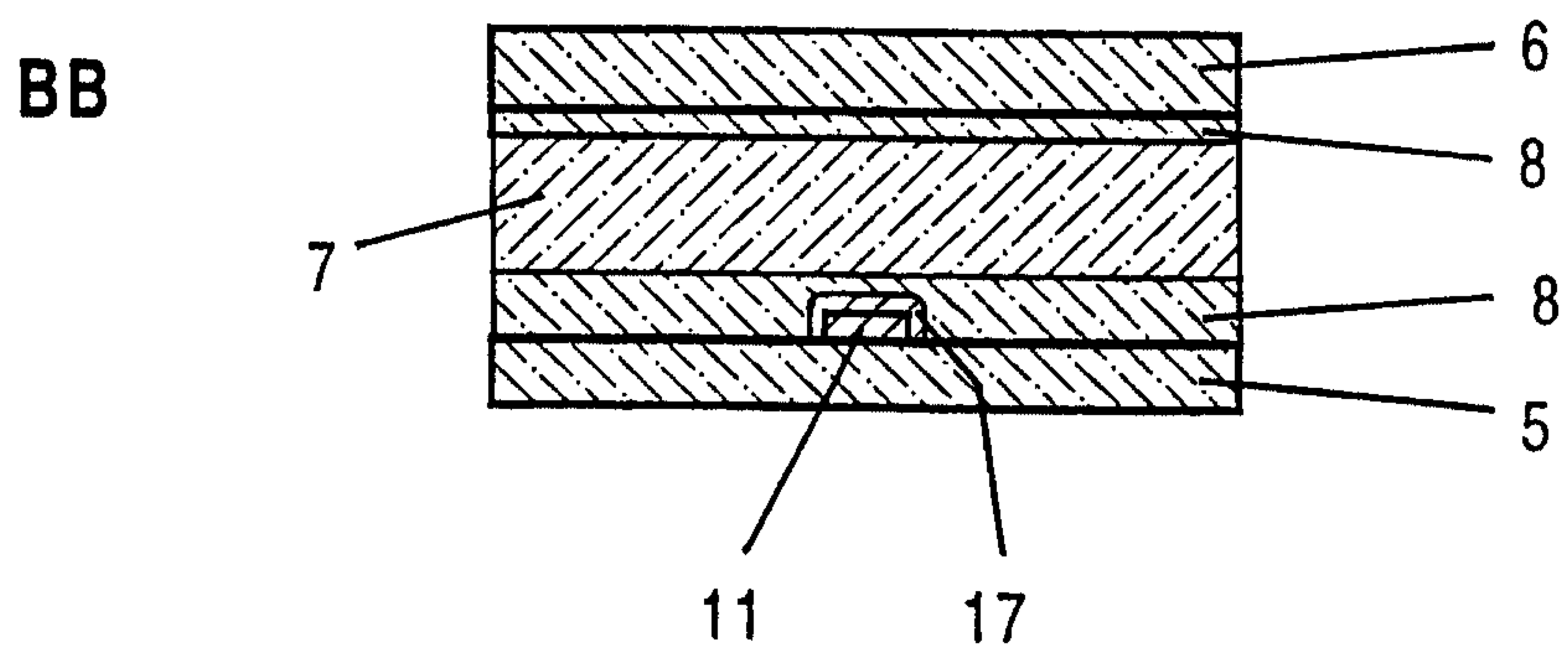
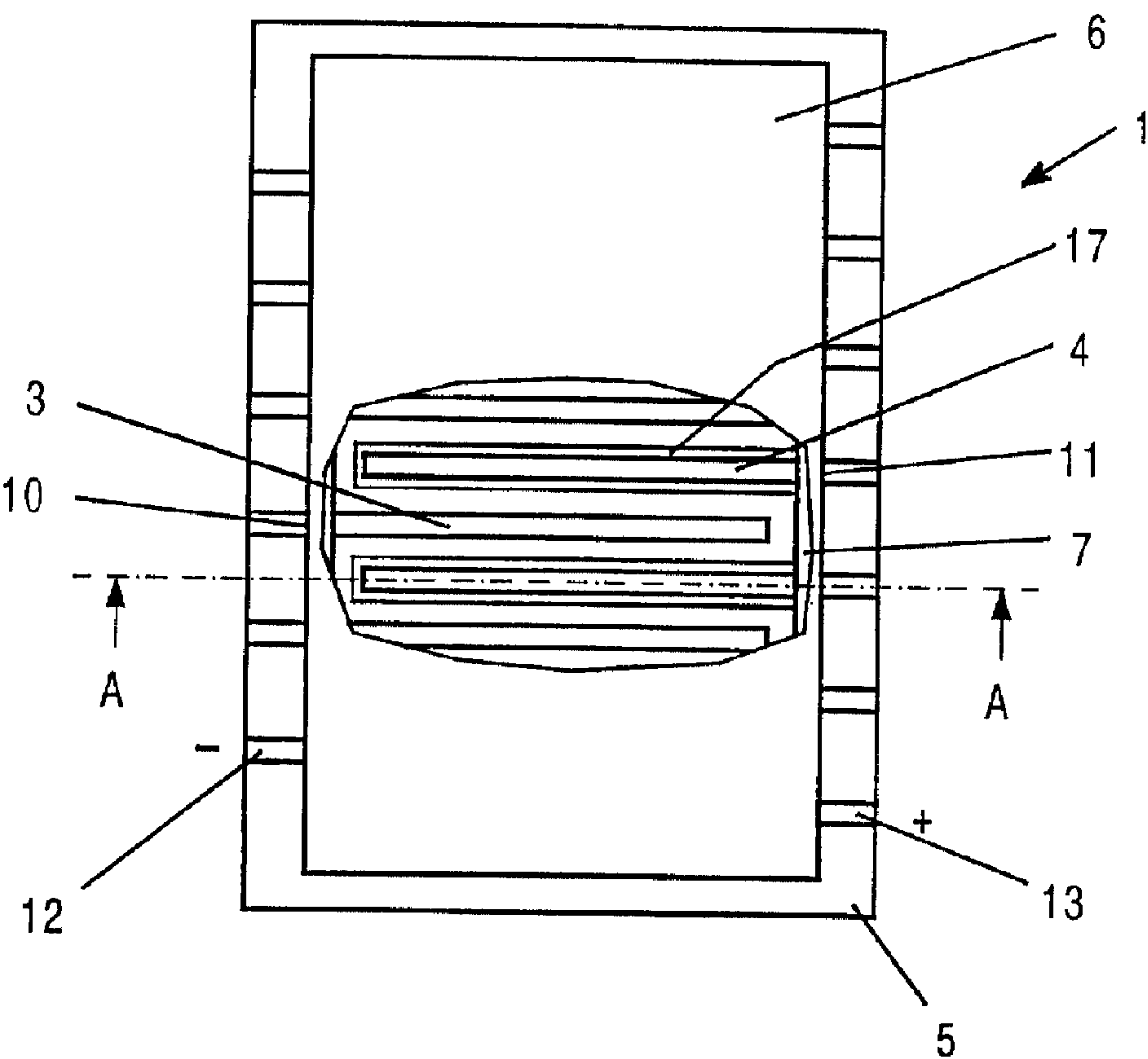


FIG. 2c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