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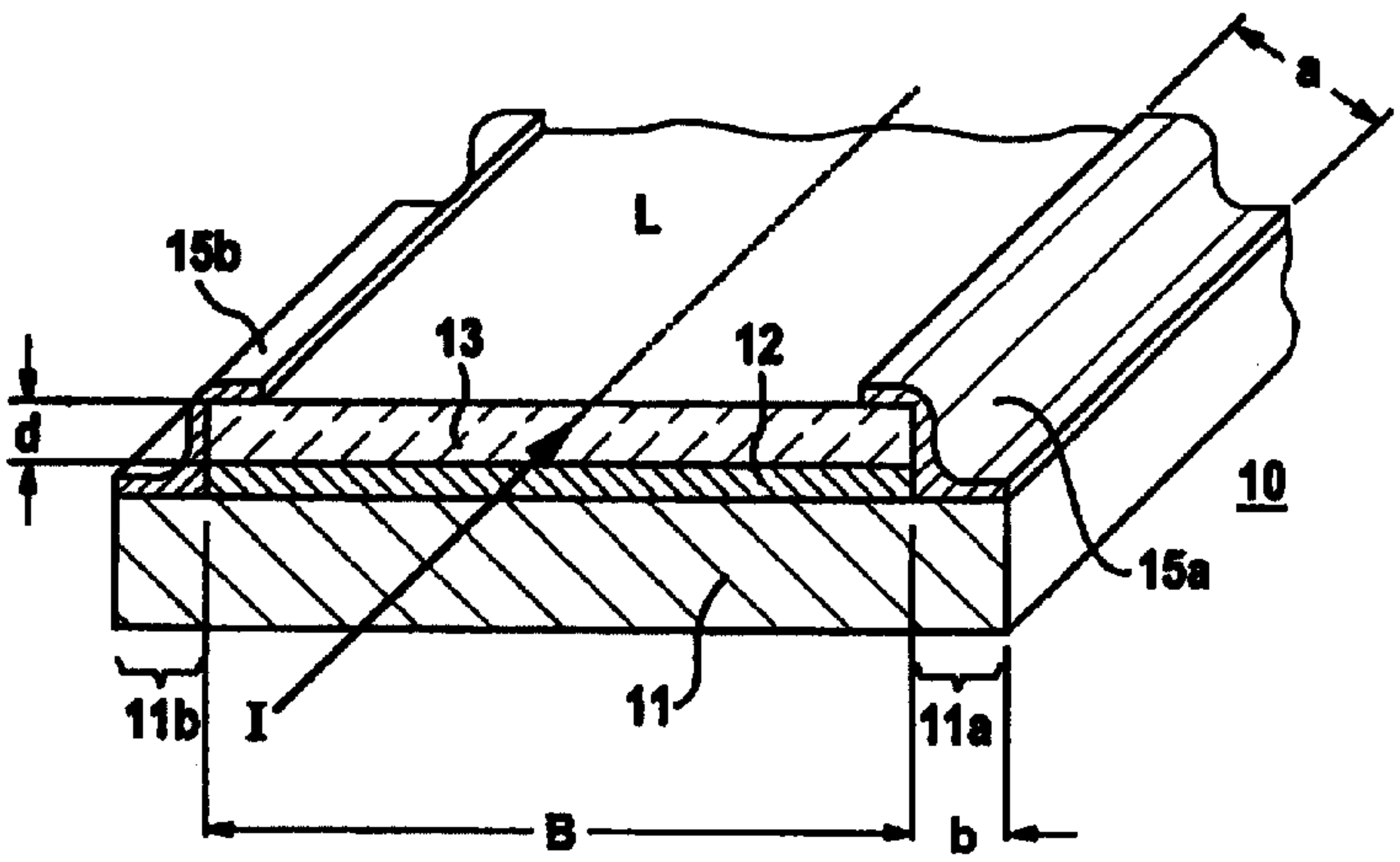
(54) **STRUCTURE SUPRACONDUCTRICE EN MATERIAU SUPRACONDUCTEUR A COEFFICIENT DE TEMPERATURE ELEVE, PROCEDE DE PRODUCTION DE CETTE STRUCTURE ET DISPOSITIF DE LIMITATION DE COURANT DOTE D'UNE TELLE STRUCTURE**

(54) **SUPERCONDUCTOR STRUCTURE WITH HIGH-T_C SUPERCONDUCTOR MATERIAL, METHOD FOR PRODUCING SAID STRUCTURE AND CURRENT-LIMITING DEVICE WITH A STRUCTURE OF THIS TYPE**



(57) L'invention concerne une structure supraconductrice (10) destinée à acheminer un courant électrique (I) dans un sens déterminé. Cette structure possède un support métallique (11) et au moins un conducteur imprimé (L) doté au moins d'une couche intermédiaire (2) électriquement isolée et au moins d'une couche supraconductrice à coefficient de température élevé (13) déposée sur la couche intermédiaire (12). Le conducteur imprimé (L) doit comprendre au moins un élément de liaison (15a, 15b) qui est intercalé entre sa couche supraconductrice (13) et le support (11), qui s'étend dans le sens de parcours du courant et qui est destiné au montage électrique en parallèle de la couche intermédiaire et du support. La structure supraconductrice peut notamment être utilisée dans un dispositif de limitation de courant.

(57) The inventive superconductor structure (10) for conducting an electrical current (I) in a predetermined direction has a metallic support (11) and at least one printed conductor (L). Said printed conductor has at least one insulating intermediate layer (12) which is deposited on the support, and a high-T_c superconductor layer (13) which is deposited on the intermediate layer. The printed conductor (L) should comprise at least one connecting part (15a, 15b) for electrically connecting the superconductor layer and the support in parallel, said connecting part extending in the direction in which the current is conducted.

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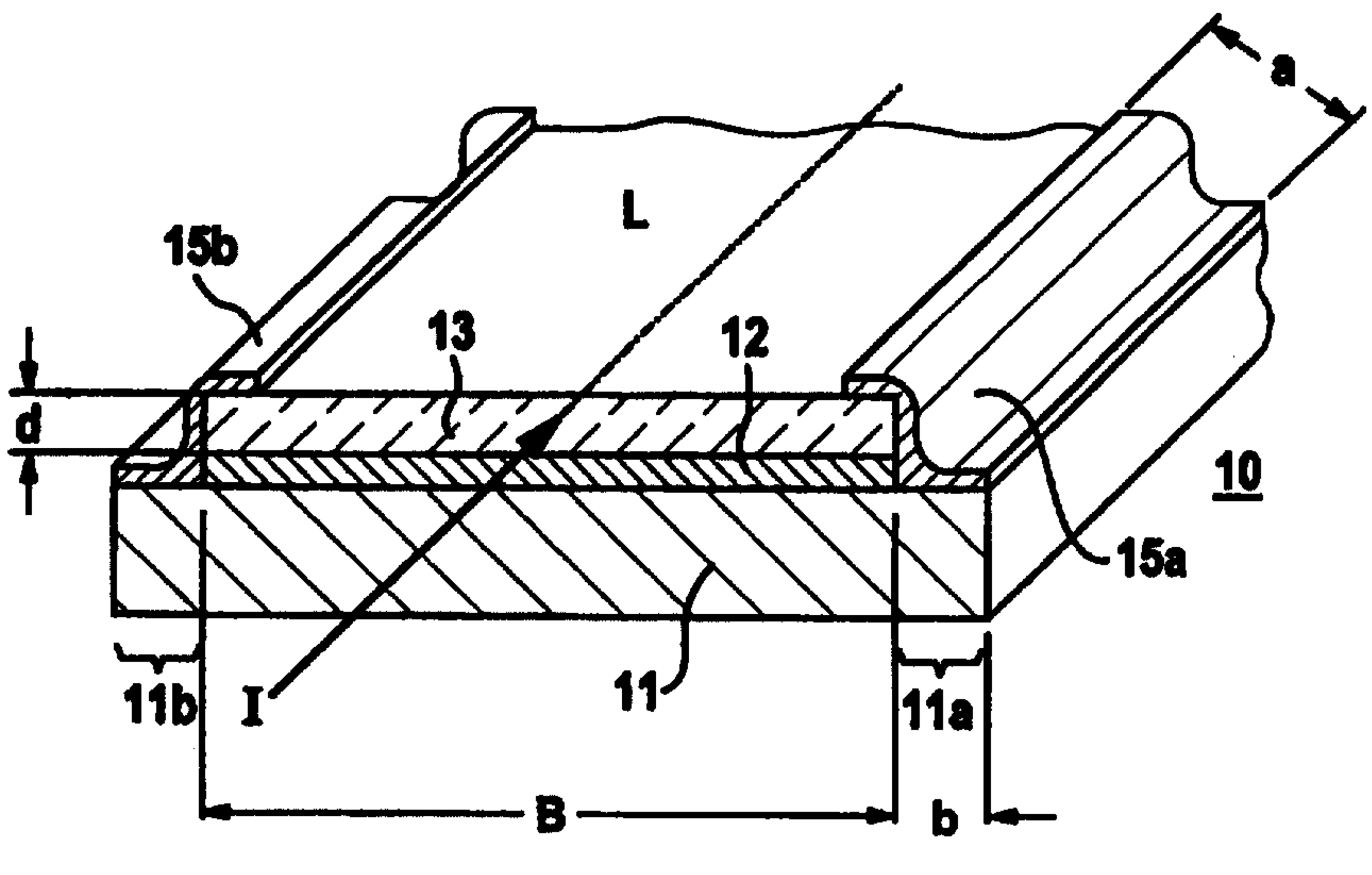
(54) Title: SUPERCONDUCTOR STRUCTURE WITH HIGH-T_c SUPERCONDUCTOR MATERIAL, METHOD FOR PRODUCING SAID STRUCTURE AND CURRENT-LIMITING DEVICE WITH A STRUCTURE OF THIS TYPE

(54) Bezeichnung: SUPRALEITERAUFBAU MIT HOCH-T_c-SUPRALEITERMATERIAL, VERFAHREN ZUR HERSTELLUNG DES AUFBAUS SOWIE STROMBEGRENZEREINRICHTUNG MIT EINEM SOLCHEN AUFBAU

(57) Abstract

The inventive superconductor structure (10) for conducting an electrical current (I) in a predetermined direction has a metallic support (11) and at least one printed conductor (L). Said printed conductor has at least one insulating intermediate layer (12) which is deposited on the support, and a high-T_c superconductor layer (13) which is deposited on the intermediate layer. The printed conductor (L) should comprise at least one connecting part (15a, 15b) for electrically connecting the superconductor layer and the support in parallel, said connecting part extending in the direction in which the current is conducted.



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Description

Superconductor construction with high T_c superconductor material, process for producing the construction, and current limiter device having such a construction

The invention relates to a superconductor construction for conducting an electric current in a predetermined direction, having at least the following parts: The construction has a support made from metallic material and a conductor track which is located on the support. This conductor track at least contains at least one interlayer which is deposited on the support and is made from electrically insulating material and at least one superconducting layer which is deposited on the interlayer and is made from a high T_c superconductor material. The invention furthermore relates to a process for producing a corresponding superconductor construction. Such a construction and a corresponding production process can be found in EP 0 292 959 A. The invention furthermore relates to a current limiter device having such a superconductor construction.

Superconducting metal oxide compounds with high critical temperatures T_c of over 77 K are known and are therefore also referred to as high T_c superconductor materials or HTS materials and allow in particular a liquid nitrogen (LN_2) cooling technique. Such metal oxide compounds include in particular cuprates based on special material systems, such as for example of the types Y-Ba-Cu-O or Bi-Sr-Ca-Cu-O, in which the Bi component may be partially substituted by Pb. Within individual material systems there may be a plurality of superconducting high T_c phases which differ through the number of copper-oxygen lattice planes or layers within the crystalline unit cell and have different critical temperatures T_c.

It is attempted to deposit these known HTS materials on different substrates for various applications, superconductor material with the maximum possible phase purity generally being sought. For example, in particular metal substrates are provided for conductor applications (cf. the EP-A document referred to above).

In a corresponding superconductor construction for conductor applications, the HTS material is generally not deposited directly on a metal support strip serving as a substrate; rather, this support strip is firstly covered with a thin interlayer, which is also known as a buffer layer. This interlayer, with a thickness of the order of magnitude of about 1 μm, is intended to prevent metal atoms from the substrate, which could impair the superconducting properties, from diffusing into the HTS material. At the same time, this interlayer can be used to smooth the surface and improve the adhesion of the HTS material. Appropriate interlayers generally comprise oxides of metals such as zirconium, cerium, yttrium, aluminum, strontium or magnesium and are therefore electrically insulating. In a discrete current-carrying conductor track, such as for example a strip conductor, this results in problems as soon as the superconductor changes to the normally conductive state at least in partial regions (known as quenching). This means that in sections the superconductor becomes resistive and thus adopts a resistance R, for example as a result of being heated beyond the critical temperature T_c (so-called hotspots). The current I which is being conducted in the superconductor then continues to flow through the superconductor material, the voltage drop $U=R \cdot I$ forming only over the region which has become resistive. By contrast, in a metal substrate which is in strip form and supports the superconducting conductor track, the voltage U which is applied at the ends drops uniformly over the entire length of the conductor. Under certain circumstances, this may result in high voltage differences in the conductor track across the interlayer. Owing to the small thickness of this layer, this inevitably leads to electrical sparkovers and thus to the interlayer, and possibly the superconductor, being destroyed at certain points. A similar problem arises inter alia when superconductors of corresponding structure are used in magnet windings or in cables. This problem also arises in particular if resistive current limiter devices are produced using corresponding conductor strips. This is because in such a device the transition from the superconducting state to the normally conducting state is utilized to limit current in the event of a short circuit. In this case, it is impossible to provide the interlayer with a sufficient dielectric strength to withstand the operating voltages in the kV range which are customary for such devices.

In view of this problem, in a known current limiter device (cf. DE 195 20 205 A), the HTS material is applied to electrically insulating, for example ceramic, substrate plates. It is also possible for an additional metal layer made from a material with a good electrical conductivity, such as Au or Ag, to be deposited directly on the HTS material as a shunt against burning through at the so-called hotspots, with the result that the HTS material is thus in electrically conductive surface-to-surface contact with the metal layer (cf. DE 44 34 819 C). In this case, the abovementioned voltage problem does not arise.

The object of the present invention is, in a superconductor construction having the features mentioned in the introduction, to at least reduce the risk of undesirable voltage differences in the conductor track across the electrically insulating interlayer using a metal support.

According to the invention, this object is achieved by the fact that at least one electrically conductive connecting part, which is assigned to the conductor track and extends in the current-conducting direction, is formed between the superconducting layer of the conductor track and the support, by means of which connecting part the superconducting layer is electrically connected in parallel with the support.

The advantages associated with this design of the superconductor construction are that the metal support and the superconducting layer of the conductor track, as seen in the current-conducting direction, are brought into electrical contact with one another at least over a large part of the length of the construction, so that current can pass between them at least in that area. Consequently, sparkover through the interlayer is advantageously suppressed in the conductor track at the connecting regions.

Advantageously, the at least one electrically conductive connecting part between the superconducting layer and the support may be formed by the fact that in the corresponding at least one connecting region deposition of the interlayer is avoided or the interlayer is removed prior to the deposition of the superconducting layer. Alternatively, it is also possible for at least one metal layer part which extends over the corresponding at least one connecting region to be deposited.

Moreover, the superconductor construction can also advantageously be produced by providing simultaneous thermal vapor deposition of the individual components of the superconductor material while oxygen is being supplied, or a laser ablation process, or a sputtering process, or a chemical vapor deposition process, in particular with organometal components of the superconductor material, or a screen-printing process as the deposition process for the superconductor material. The abovementioned deposition process can produce superconducting layers with a high critical current density on the interlayer.

Furthermore, it is advantageous if an ion beam assisted deposition (IBAD) process is provided for deposition of the interlayer material. This process can be used in particular to produce biaxially textured crystal structures of known interlayer materials. The superconductor material then advantageously also grows on in biaxially textured form, so that high critical current densities can be achieved by the absence of current-limiting grain boundaries.

Particularly advantageously, the superconductor construction according to the invention may be for the purpose of forming a current limiter device, because the use of a metal support for the superconductor material ensures rapid dissipation of heat to the cryogenic medium required and thus ensures a correspondingly rapid switching sequence.

Advantageous configurations of the superconductor construction according to the invention, of the process for its production and of the current limiter device produced using this superconductor construction are given in the corresponding dependent claims.

Exemplary embodiments within the scope of the invention are explained below with reference to the drawing, in which, in each case diagrammatically:

Figures 1 and 2 show two theoretically possible designs of the superconductor construction,

Figure 3 shows a specific embodiment of the construction shown in Figure 2,

Figure 4 shows the flow of current in a superconductor construction in the case of a quench,

Figure 5 shows a modular current limiter element produced from the superconductor construction, and

Figure 6 shows a current limiter device having a plurality of modular current limiter elements in accordance with Figure 5.

Throughout the figures, corresponding parts are provided with identical reference symbols.

Designs which are known per se (cf. EP 0 292 959 A, mentioned in the introduction) as provided in particular also for superconducting current limiter devices (cf. DE 195 20 205 A or EP 0 523 374 A, which have also been mentioned above), form the basis for the design of the superconductor construction according to the invention. The superconductor construction according to the invention therefore at least comprises: a support, which can also be referred to as a substrate, and at least one conductor track located thereon. This conductor track comprises at least one interlayer which is deposited on the support and can also be referred to as a buffer layer, and a layer of an HTS material which is applied to this interlayer. The two layers are structured so as to form the conductor track. A plate or a strip or other structure made from a metallic material with any desired thickness and the surface dimensions which are required for the particular application is used for the support. Suitable metallic materials for this purpose are all elemental metals or alloys of these metals which are known as supports for HTS materials. By way of example, Cu, Al or Ag or their alloys with one of the elements as the principal component or steels, as well as special NiMo alloys, in particular known by the trade name "Hastelloy", are suitable.

To enable textured, in particular epitaxial growth of the HTS material, which is required for a high critical current density J_c of the HTS material, to be achieved, the at least one interlayer should consist of a material which ensures such growth. Therefore, an interlayer with a texture which is matched to the crystalline dimension of the HTS material is particularly suitable. In all cases, the interlayer material should be electrically insulating. Biaxially textured, yttrium-stabilized zirconium oxide (for short: "YSZ") is advantageous. In addition, other known buffer layer materials, such as for example CeO_2, YSZ + CeO_2 (as a double layer), Pr_6O_{11}, MgO, YSZ + tin-doped In_2O_3 (as a double layer), $SrTiO_3$ or $La_{1-x}Ca_xMnO_3$ are also suitable. One or more of these materials is deposited on the surface of the support in a manner known per se. A so-called IBAD process (Ion Beam Assisted Deposition process) may advantageously be provided for this purpose. Naturally, other processes are also suitable, such as for example sputtering or laser ablation at a predetermined angle. The interlayer material is in most cases deposited at elevated temperatures on the support. The layer thickness of the textured interlayer produced in this way is generally between 0.1 and 2 µm.

Then, the HTS material is applied to the interlayer using known deposition processes and while the support is being heated, with a thickness of generally up to a few micrometers. The most customary of the appropriate processes of the PVD (Physical Vapor Deposition) technique are laser ablation using a pulsed laser, magnetron sputtering or preferably thermal vapor codeposition (= simultaneous vapor deposition of the components of the HTS material while oxygen is being supplied). CVD (Chemical Vapor Deposition) processes, in particular using organometal starting materials, are also suitable. Alternatively, a screen-printing process which is known per se may also be provided.

Suitable HTS materials are all known metal oxide high T_c superconductor materials which in particular allow an LN_2 cooling technique to be used. Examples of appropriate materials are $YBa_2Cu_3O_{7-x}$ or $RBa_2Cu_3O_{7-x}$ (where R = rare earth element), $HgBa_2CaCu_2O_{6+x}$, $HgBa_2Ca_2Cu_3O_{8+x}$, $Bi_2Sr_2CaCu_2O_{8+x}$ or $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+x}$. The HTS layer may be covered with at least one further layer, such as for example a protective layer or a layer serving as a shunt resistor.

The interlayer and the HTS layer located thereon are structured to form at least one conductor track. It is also possible to provide layer tracks which have been deposited discretely in an appropriate manner.

A corresponding superconductor construction according to the invention comprising strip-like support, interlayer and HTS layer also forms the basis of the exemplary embodiment which is shown in cross section in Figure 1 and is denoted overall by 10. In this figure, the support is denoted by 11, the interlayer by 12 and the HTS layer by 13. The interlayer 12 and the HTS layer 13 form a conductor track L in strip form. According to the invention, at least one electrically conductive connecting part, which extends in the direction in which an electric current I is conducted, indicated by an arrow, is to be present between the HTS layer 13 and the support 11 of the conductor track L. This means that, as seen in this direction, the superconducting layer is to be connected in parallel with the support by means of the at least one connecting part over the entire length of the construction, i.e. without interruption. However, it is also possible for regularly distributed interruptions, which are short as seen in this direction, to be provided in the connection between these parts without the desired parallel connection being significantly impaired. According to the exemplary embodiment shown, two connecting parts in the form of lateral, strip-like layers 15a and 15b are formed from a metal with a good electrical conductivity, such as Ag, Au or Cu. To produce these strip-like metal layers 15a and

15b, in at least one of the two lateral, strip-like edge areas 11a and 11b of the strip-like support 11, the buffer layer 12 is either not applied at all during deposition, for example by using a shadow mask, or is removed by mechanical or chemical processes following this, such as grinding, etching, vaporization using a laser beam. The width b of these edge areas 11a and 11b of the support, which are now bare, should advantageously be in each case at least five times the thickness d of the HTS layer 13, but preferably significantly more, up to one hundred times this thickness. The contact between the HTS layer 13 and the support 11 is then brought about through the application of the strip-like metal layers 15a and 15b, which extend laterally beyond the interlayer 12 and cover the corresponding edge area of the superconductor layer and the bare edge areas 11a and 11b of the support. The HTS layer may, like the interlayer, have been removed in the edge areas 11a and 11b or alternatively may extend beyond these areas. In general, the lateral extent a of the metal layers 15a and 15b is short, preferably 1/10 to 1/100, compared to the width B of the strip-like superconductor layer 13 or the interlayer 12 located beneath it. The maximum thickness of these metal layers is generally at most equal to the thickness d of the HTS layer 13.

In the superconductor construction according to the invention which is shown in Figure 2 and is denoted overall by 20, the HTS layer 23 of its conductor track L extends laterally beyond the narrower interlayer 22, as far as the entire width of the support 11. Consequently, in this embodiment no special metal strips are required to provide the contact, but rather the HTS layer is in direct electrical contact with the support in the edge areas 11a and 11b of the support 11, since it laterally overlaps the interlayer 22. In this case, in the area of the edge of the interlayer 22 and on the edge areas 11a and 11b, the superconducting characteristics, such as the critical current density J_c and/or the critical temperature T_c, may be reduced in the corresponding edge strips 23a and 23b of the HTS layer 23. If appropriate, the material of the layer 13 may even be normally conductive in these areas.

As an alternative to the embodiments of a superconductor construction 10 and 20 according to the invention illustrated in Figures 1 and 2, respectively, in which the electrically conductive connection, as seen in the current-conducting direction, between the HTS layer of a conductor track L and the metallic support extends over practically the entire axial length of the construction, it is also possible for these two parts of the construction to be in contact with one another but with regular interruptions in this direction. Figure 3 shows a corresponding superconductor construction 30. In this construction, as in the embodiment shown in Figure 2, the contact is brought about by the HTS layer 33 itself. For this purpose, in an interlayer 32 recesses 35, which are, for example, triangular and in which the HTS layer 33 rests directly on the support 11, are provided at regular intervals one behind the other in the current-conducting direction. In this case, therefore, the interlayer 32 has, as it were, a toothed lateral contour, the mean tooth width w advantageously being at least 5 times the thickness d of the HTS layer 33. In this way, it is advantageously possible to extend the length of the overheating zone between the superconducting material of the conductor track and the metallic support, the transfer resistance being correspondingly reduced.

In the exemplary embodiments of a superconductor construction according to the invention which are shown in Figures 1 to 3, it has been assumed that a single strip-like conductor track L is formed on a support 11 and the support additionally has a shape which is matched to the strip shape of the conductor track. Of course, supports whose width is relatively great are also suitable for a superconductor construction according to the invention. If the support is of sufficient size, it is then also possible for a plurality of conductor tracks to be arranged thereon. Figure 4 shows, in an illustration corresponding to Figure 2, such a superconductor construction, in which two parallel conductor tracks L and L′, each having a layer construction as shown in Figure 2, are situated on a common support 11.

A cross section corresponding to Figure 4 would also result if a single conductor track of looped or U-shaped or meandering form were to be formed on the support.

Figure 5 shows a plan view of a strip-like superconductor construction in accordance in Figure 1 or Figure 2. By way of example, the construction 20 shown in Figure 2 with conductor track L is assumed. A partial section 23t, which is shaded, of the HTS layer 23 of this conductor track is assumed to have become normally conductive (resistive). The flow of the current I which is then established is indicated by current lines, the current lines in the HTS layer 23 being denoted by i and illustrated by solid lines, while the current lines i′ extending through the support are shown by dashed lines. If the resistance of the resistive partial section 23t is high compared to the parallel section of the support strip, most of the current I is diverted, parallel to the resistive partial section 23t, via the electrical connection provided by the edge strips 23a and 23b at the edges, into the metallic support. An analysis of the two-dimensional current distribution in a strip-like superconductor construction shows that a cross over zone Z approximately has an axial extent $\Delta l = B/\pi$, where B is the width of the HTS layer. In this way, a voltage difference across the insulating interlayer 22 of the conductor track L is reduced to a tolerable level in the region of a few volts. The metallic support additionally acts as a shunt resistor for the superconductor and, for example in a current limiter device, advantageously obviates the need for additional application of a low-resistance film made from material with a good conductivity, such as Ag or Au, to the surface of the HTS layer in order, if appropriate, to avoid unacceptable heating of the superconductor section in a hotspot which has become prematurely normally conductive.

Particularly advantageously, the superconductor construction according to the invention may be provided for a resistive current limiter device. For this purpose, by way of example a large-surface-area, plate-like construction or, as assumed below, a strip conductor type in accordance with one of the embodiments shown in Figures 1 and 3 forms the basis, in which a $YBa_2Cu_3O_{7-x}$ layer with a thickness of approximately 0.3 to 10 µm is applied to a preferably textured interlayer (buffer layer) of its conductor track L. The corresponding strip conductor then carries the current without resistance until the critical current J_c is reached and, after it has become normally conductive (quenched) as a result of J_c being exceeded, has a sufficiently high resistance to effectively limit a fault current in the event of a short circuit. The metal strip of the support at the same time acts as shunt for the superconductor layer and limits the temperature increase in "hotspots" which have prematurely become normally conductive. To keep the length of the strip conductor as short as possible, its support should be as thin as possible, in particular should be between 0.03 and 0.1 mm thick, and should consist of a metal with a high specific electrical resistance, such as of Hastelloy in particular. Advantageously, in accordance with the illustration shown in Figure 6, it is possible to form a low-inductance, modular limiter element 50 by parallel winding of strip conductors 20 and 20', which are electrically connected to one another at a common end 51, to form a bifilar disc winding 52. Insulating strips 53 for electrical insulation are inserted between adjacent strip layers of the winding 52, which insulating strips, for example by means of a corrugated or ribbed structure, at the same time make it easier for a coolant to gain access to the strip conductors for the purpose of rapid recooling after a switching operation. The figure also shows connection conductors 54a and 54b for the electrical connection of the strip conductor winding 52 or for supplying and discharging an electric current I.

A plurality of such modular current limiter elements 50i (where i = 1 … n·m) can be used to construct a current limiter device which is shown in Figure 7 and is denoted by 60. By means of an n-fold parallel connection of a plurality of such elements with rated current I and rated voltage U, it is then possible to form current limiter devices for specific rated currents n·I, and by an m-fold series connection for rated voltages m·U.

A current limiter device 60 in accordance with Figure 7 forms the basis for the data from a specific exemplary embodiment which are compiled below in the form of a table:

Table

1.)	Strip conductor for I_c = 400 A	
	Thickness x width support strip (11)	50 µm x 2 cm Hastelloy
	Biaxially textured interlayer (22)	1 µm Y-stabilized ZrO_2 or CeO_2
	Width (b) of bare edge areas (11a, 11b) on both sides	0.02 - 0.2 mm
	Thickness (d) $YBa_2Cu_3O_{7-x}$ superconductor layer (23)	2 µm
	Critical current density in the superconductor	10^6 A/cm^2
	Optional: Ag layer (15a, 15b) thickness x width in the edge area	1 µm x 0.1 - 0.3 mm
2.)	Modular current limiter element (50i)	
	2 strips (20, 20') according to 1.), length	2 x 7.5m bifilar winding
	Layer insulation provided by insulating strip (53)	Plastic film 25 µm, corrugated
	External diameter strip winding (52)	10 - 20 cm
3.)	Current limiter device (60i) for 2000 A_{rms}, 15 kV	
	Number of elements (50_i) in accordance with 2.)	49 (n = 7 parallel x m = 7 in series)
	Total length HTS strip (20, 20') in accordance with 1.)	L = 735 m

In accordance with the above exemplary embodiments, the assumption was a parallel connection between the superconducting layer of a conductor track and the support, in each case at the edge of the superconducting layer. However, this is not necessarily the case. For example, it is also possible for recesses or trenches or holes, which extend in the current-conducting direction and at the edges of which the parallel connection according to the invention is made, to be formed into the superconducting layer. By way of example, recesses of this nature may extend in the center of a strip-like superconducting layer. In this case, however, it must in all cases be ensured that, according to the invention, each conductor track only has its assigned connecting parts in accordance with Figures 1 to 3.

Patent Claims

1. A superconductor construction for conducting an electric current in a predetermined direction, having at least the following parts:

- a support made from metallic material,

and

- a conductor track which is located on the support and at least contains
  - at least one interlayer which is deposited on the support and is made from electrically insulating material,

  and
  - at least one superconducting layer which is deposited on the interlayer and is made from a high T_c superconductor material,

characterized in that at least one electrically conductive connecting part, which is assigned to the conductor track and extends in the current-conducting direction, of the conductor track is formed between the superconducting layer (13, 23, 33) of the conductor track (L, L′) and the support (11), by means of which connecting part the superconducting layer is electrically connected in parallel with the support.

2. The construction as claimed in claim 1, characterized in that the at least one connecting part is provided in the form of a strip-like metal layer (15a, 15b) which extends laterally from the superconducting layer (13) to an edge area (11a, 11b) of the support (11).

3. The construction as claimed in claim 1, characterized in that the at least one connecting part is provided in the form of an edge strip (23a, 23b), which laterally overlaps the interlayer (22, 32), of the superconducting layer (23), which edge strip rests on a corresponding edge area (11a, 11b) of the support (11).

4. The construction as claimed in claim 3, characterized in that the interlayer (32) is provided with lateral recesses (35), in which the superconducting layer (33) rests on the support (11).

5. The construction as claimed in one of the preceding claims, characterized by a support (11) made from Cu, Al or Ag or their alloys or from a steel, in particular from an NiMo alloy.

6. The construction as claimed in one of the preceding claims, characterized by at least one interlayer (12, 22, 32) with a texture which is matched to the crystalline dimensions of the superconductor material.

7. The construction as claimed in claim 6, characterized by at least one interlayer (12, 22, 32) made from biaxially textured, yttrium-stabilized ZrO_2 or CeO_2.

8. The construction as claimed in one of the preceding claims, characterized by a plurality of discrete conductor tracks (L, L′) on a common support (11).

9. A process for producing the superconductor construction as claimed in one of the preceding claims, characterized in that, to form the at least one connecting part between the superconducting layer (13, 23, 33) and the support (11), in the at least one connecting region deposition of the interlayer is avoided or the interlayer is removed prior to the deposition of the superconducting layer.

10. A process for producing the superconducting construction as claimed in one of claims 1 to 8, characterized in that, to form the at least one connecting part between the superconducting layer (13) and the support (11), at least one strip-like metal layer (15a, 15b) which extends over the connecting region is deposited.

11. The process as claimed in claim 9 or 10, characterized in that the deposition process for the superconductor material provided is simultaneous thermal vapor deposition of the individual components of the superconductor material while oxygen is being supplied, or a laser ablation process, or a sputtering process, or a chemical vapor deposition process, in particular with organometal components of the superconductor material, or a screen-printing process.

12. The process as claimed in one of claims 9 to 11, characterized in that an ion beam assisted deposition (IBAD) process or a sputtering process or a laser ablation process is provided for deposition of the interlayer material.

13. A current limiter device, characterized by at least one superconductor construction (10, 20, 30) as claimed in one of claims 1 to 8.

14. The current limiter device as claimed in claim 13, characterized by electrical interconnection of a plurality of modular current limiter elements (50i) which each have a superconductor construction as claimed in one of claims 1 to 8.

15. The current limiter device as claimed in claim 14, characterized in that each current limiter element (50i) has a winding (52) comprising bifilar-wound conductor strip (20, 20') having the superconductor construction.

16. The current limiter device as claimed in claim 15, characterized by strip conductor windings (52) with insulating strips (53), which make it easier for a coolant to gain access, between adjacent conductor strip layers.

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Patent Agents

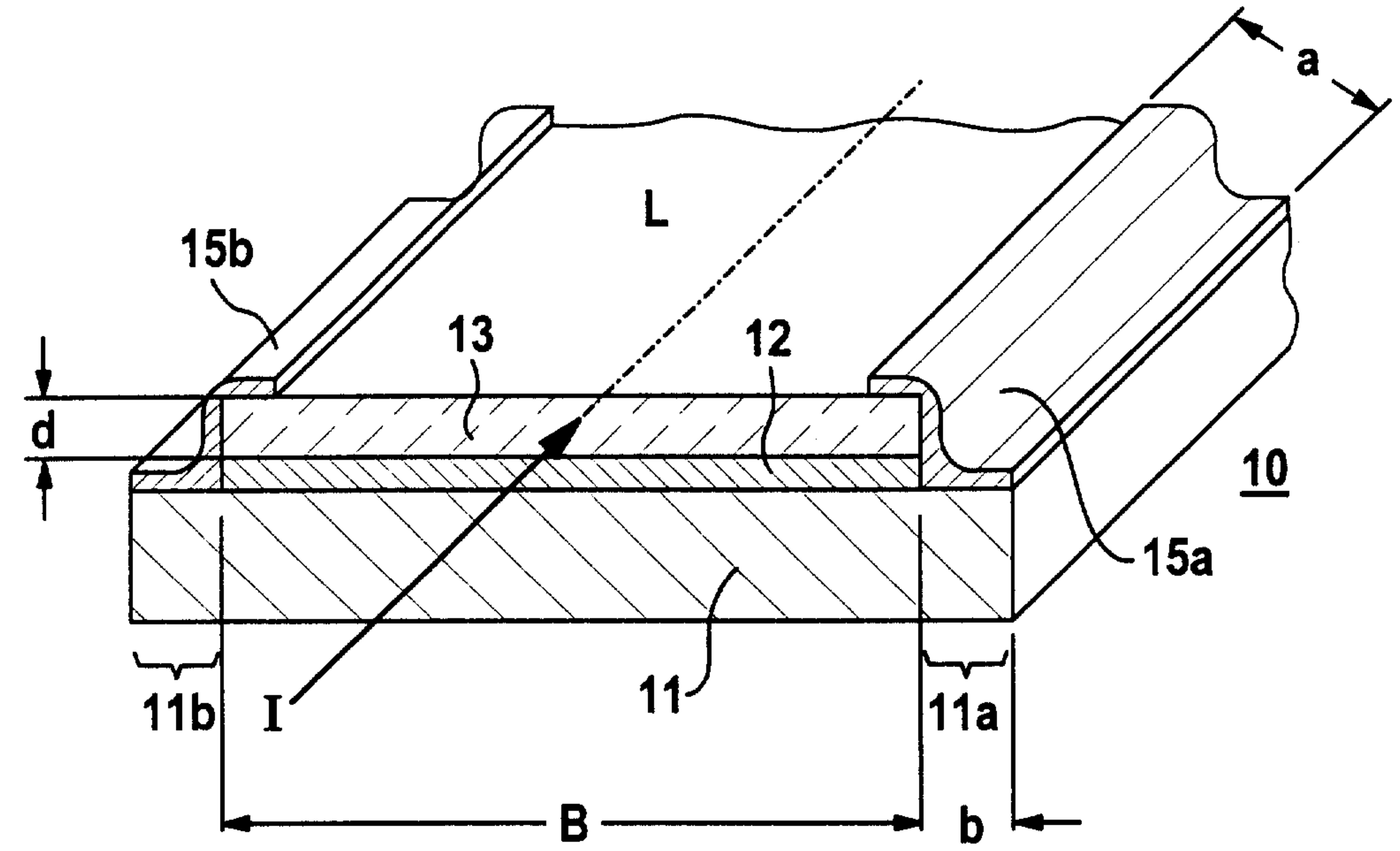

FIG 1

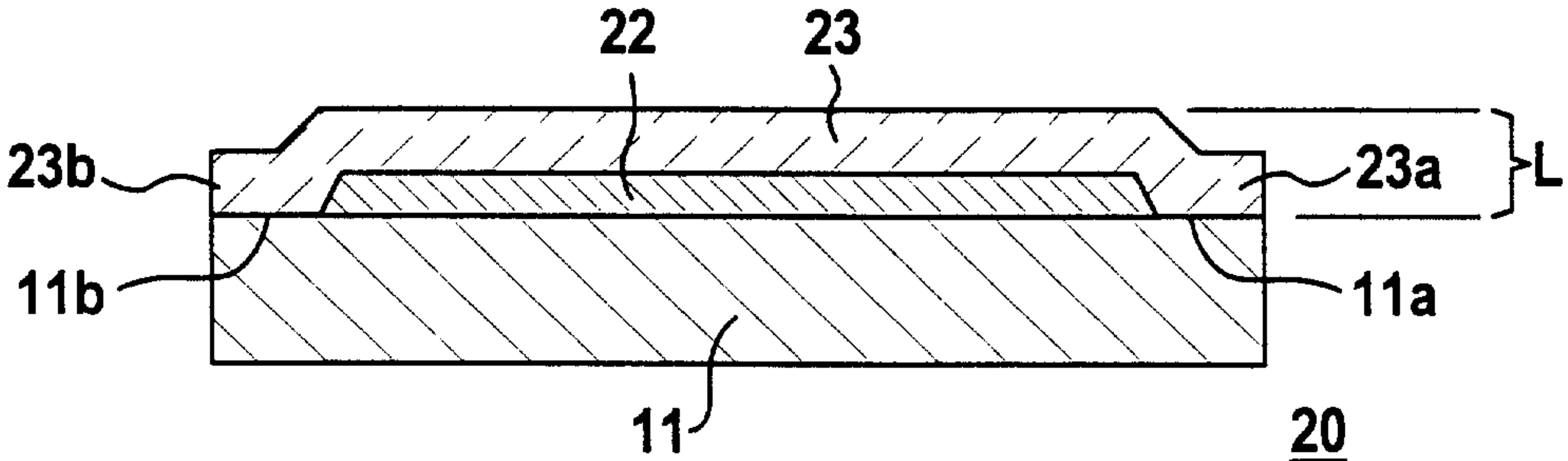

FIG 2

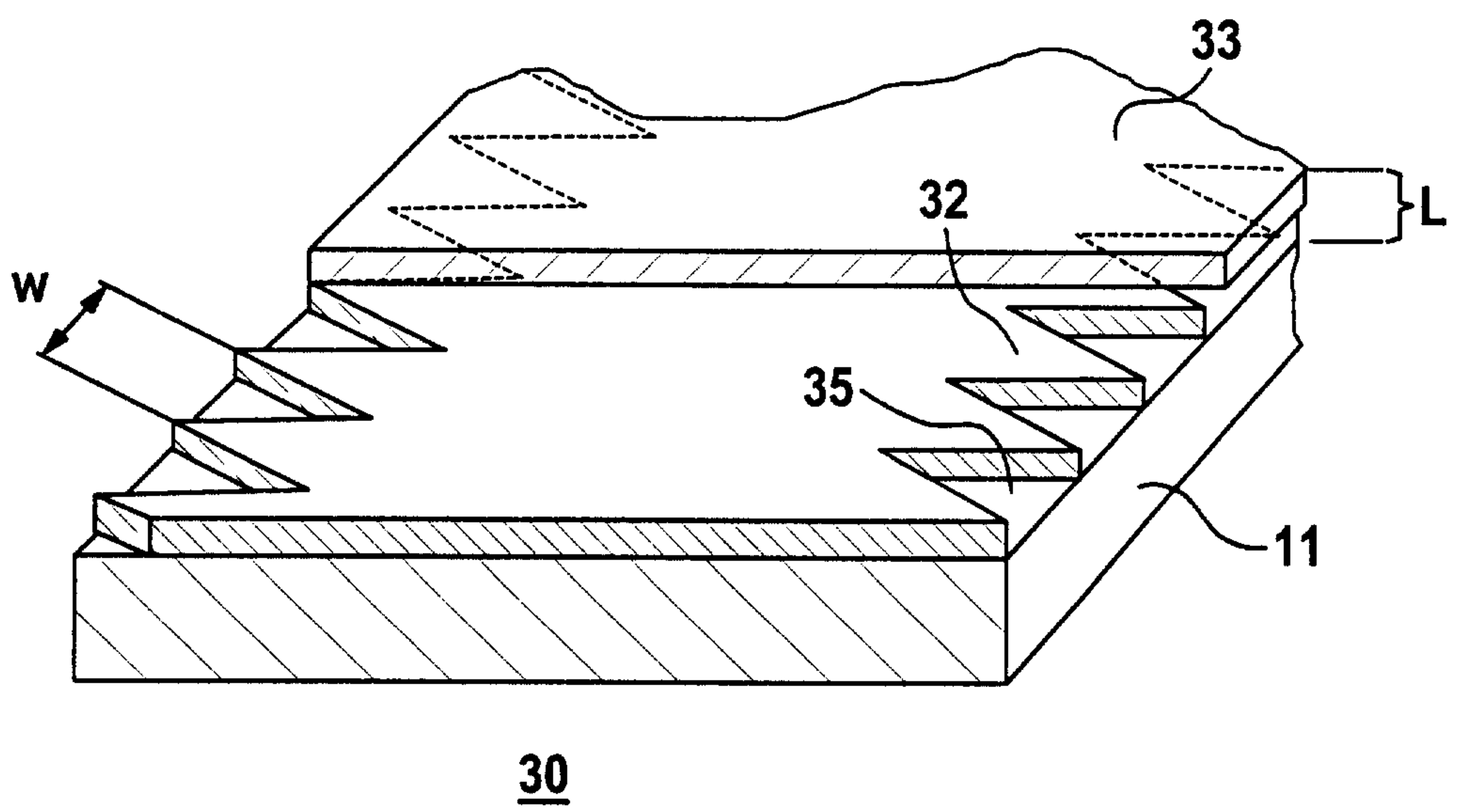

FIG 3

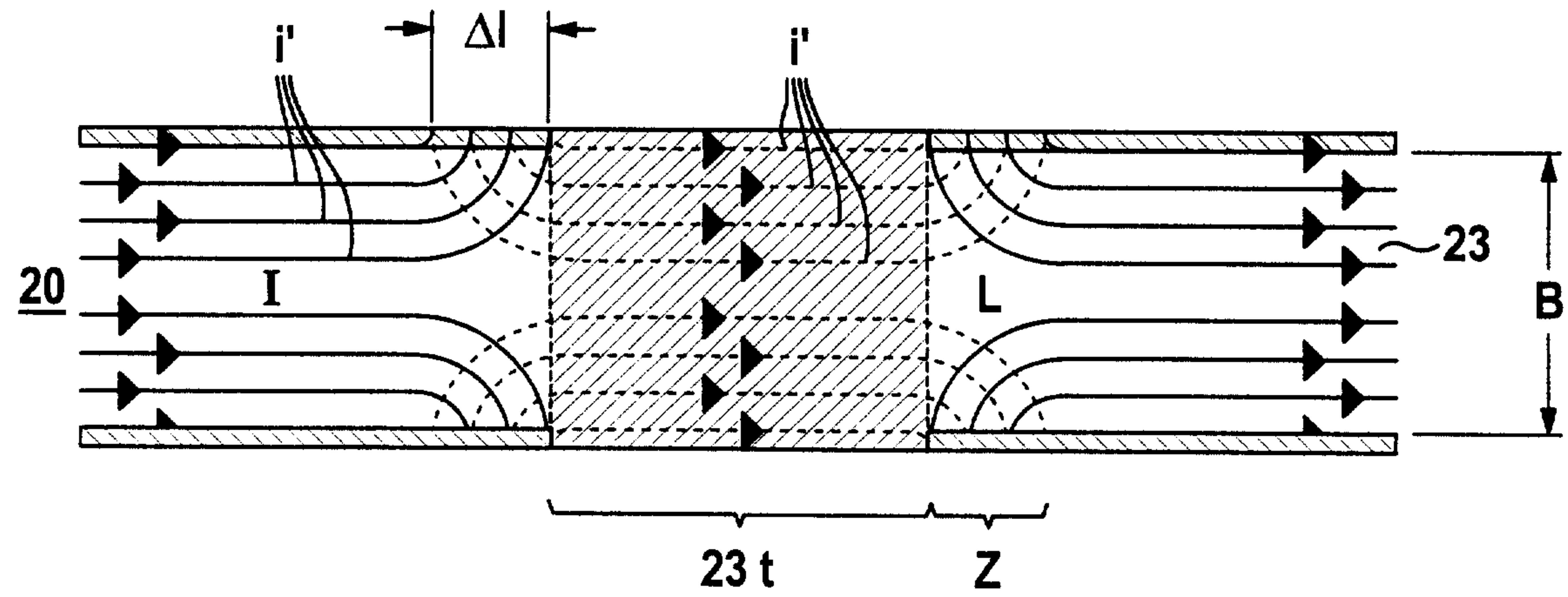

FIG 5

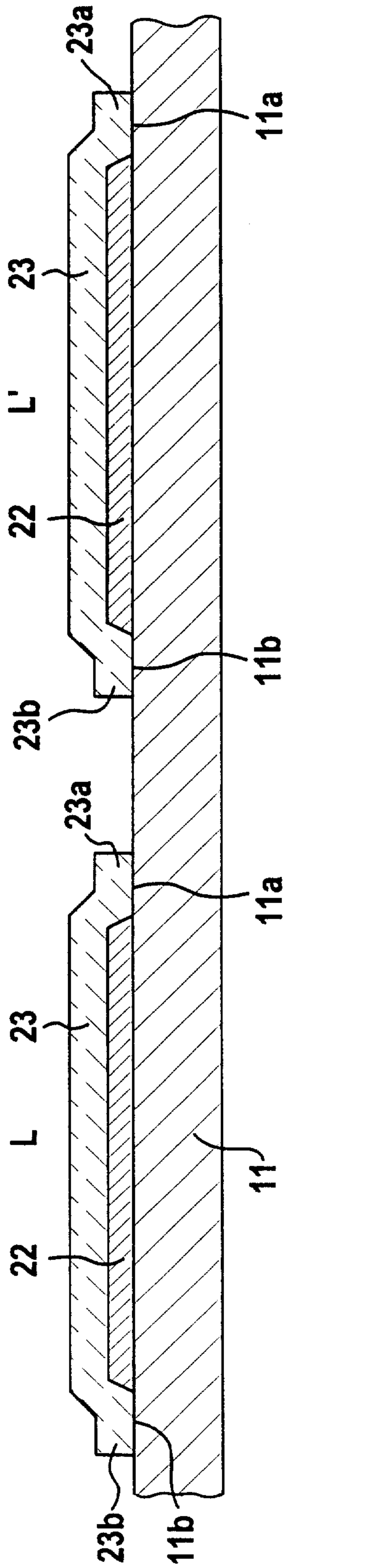

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FIG 4

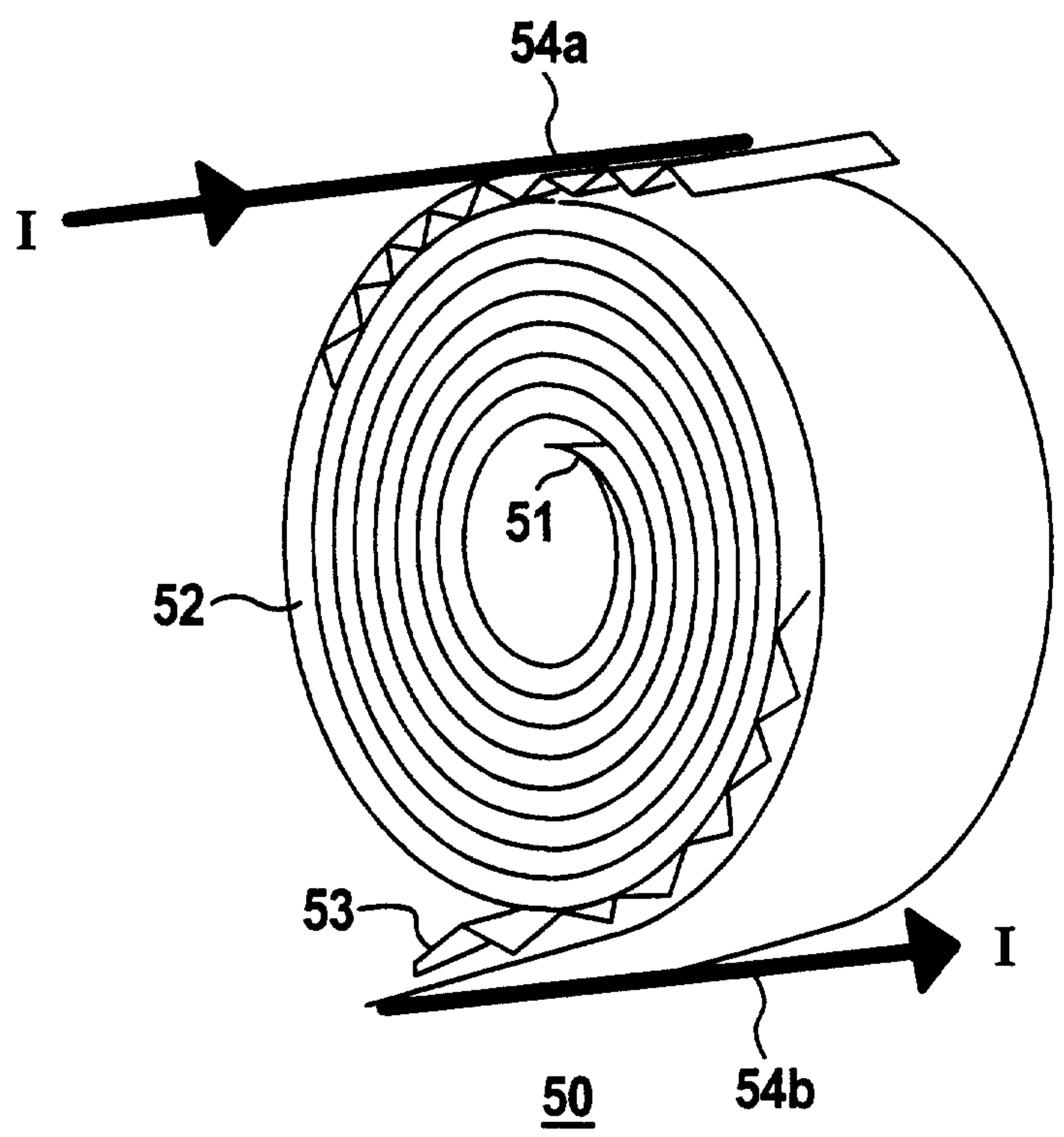


FIG 6

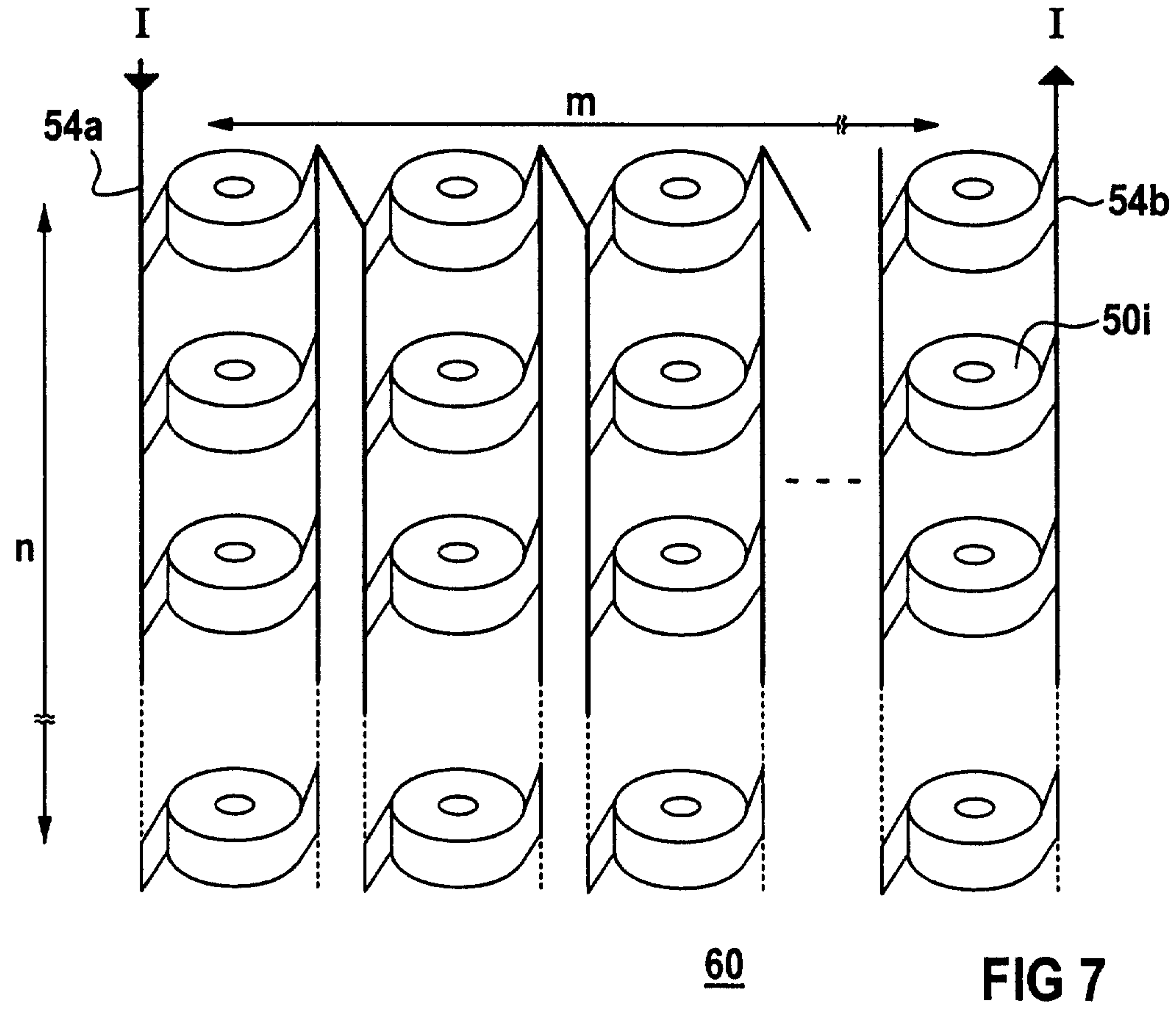
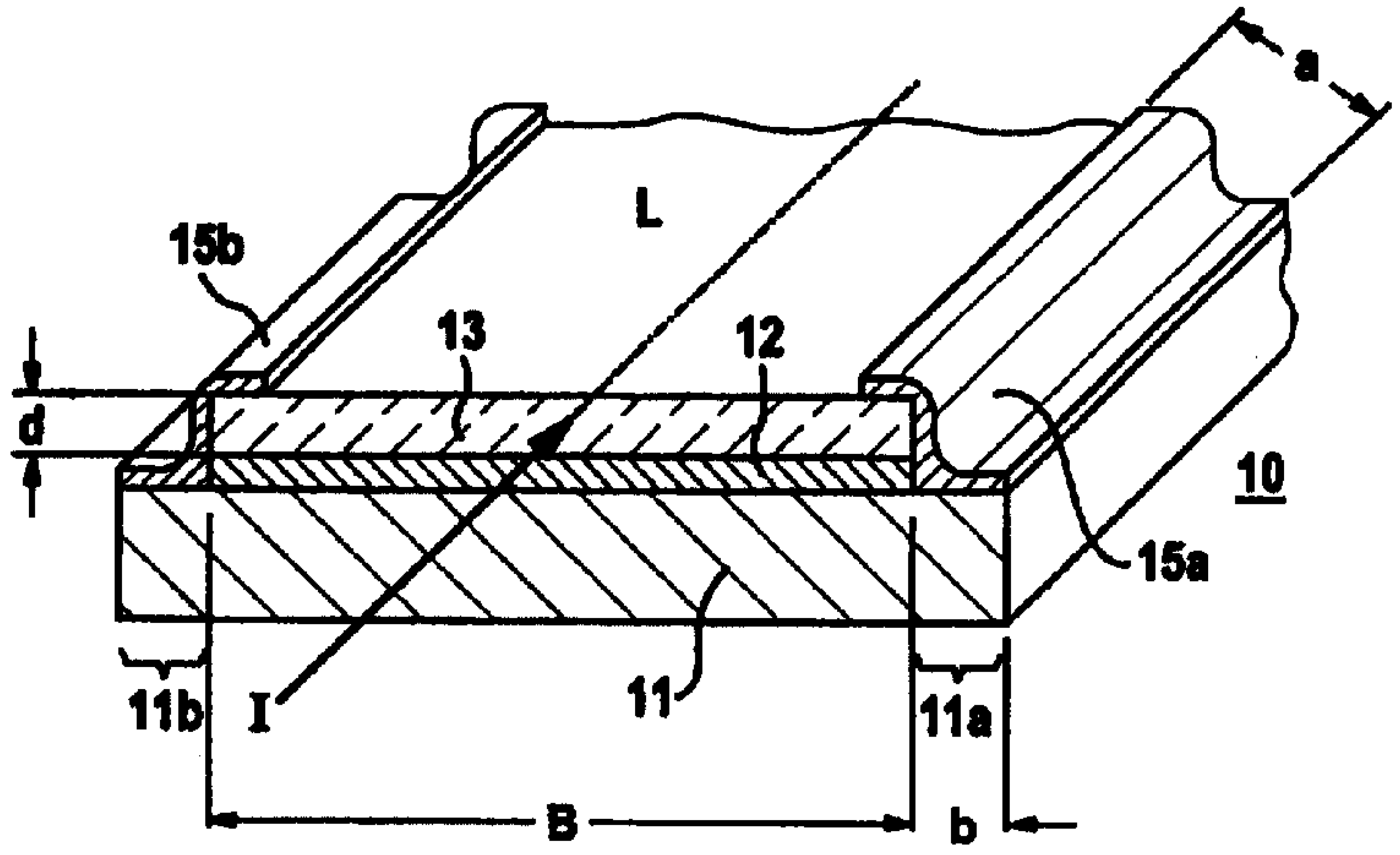


FIG 7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