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(71) Demandeur/Applicant:
SGL CARBON SE, DE

(72) Inventeurs/Inventors:
BRUCH, CHRISTIAN, DE;
HILTMANN, FRANK, DE;
DAIMER, JOHANN, DE;
BANEK, MANFRED, DE

(74) Agent: FETHERSTONHAUGH & CO.

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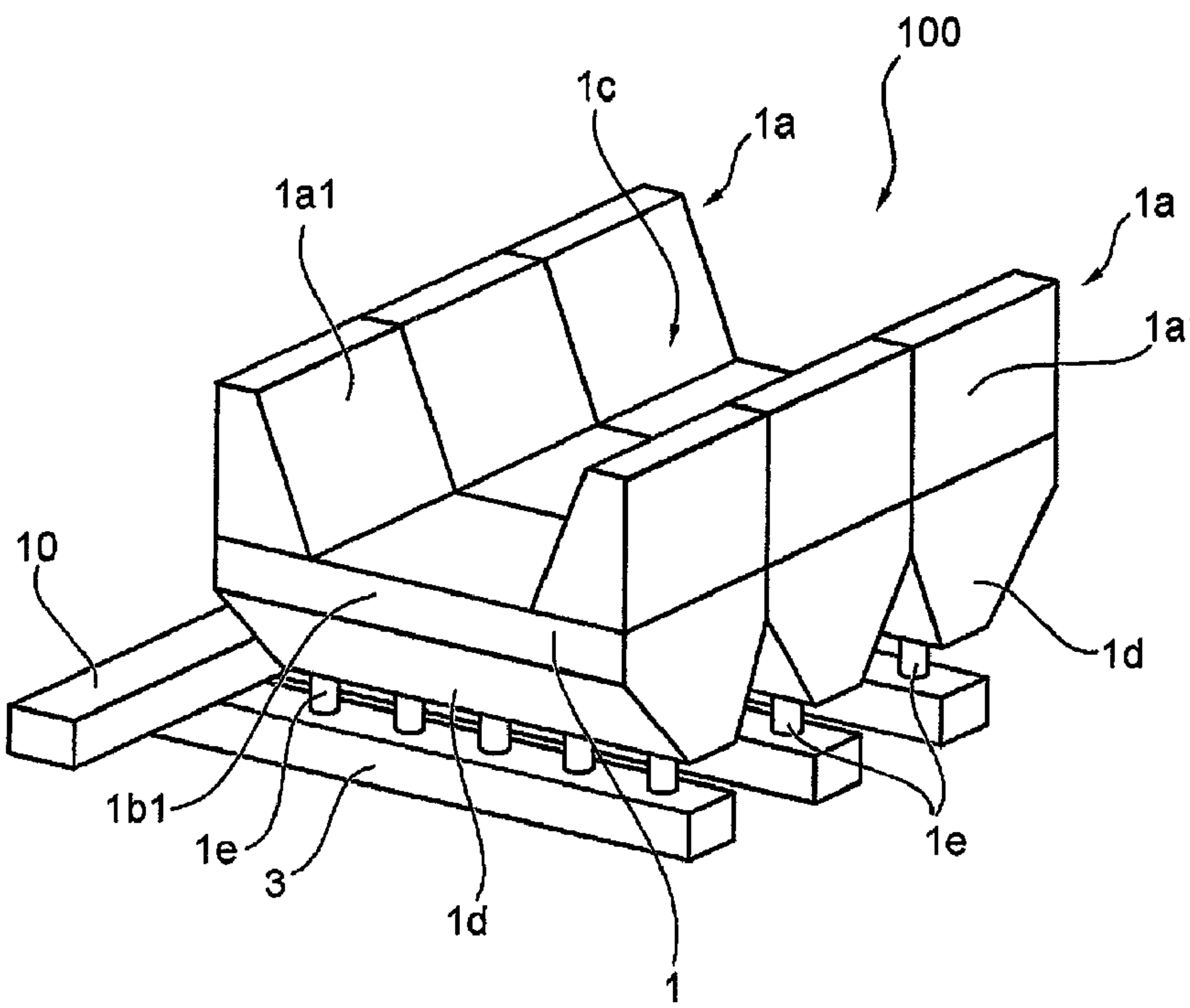

FIG. 2a

(57) Abrégé/Abstract:
The invention relates to a cathode (1) for an electrolysis cell for obtaining aluminium from its oxide, comprising a lower side (1g). According to the invention, the cathode (1) is provided with a number of rods (1f) for a power supply, said rods contacting the lower side (1g) of the cathode (1) from below during operation in a power-supplying manner.

Cathode for electrolytic cells

Abstract

The invention relates to a cathode (1) for an electrolytic cell used to extract aluminium from its oxide, exhibiting an underside (1g). According to the invention, the cathode (1) is provided with a number of pins (1f) for a current supply, wherein the pins contact the underside (1g) of the cathode (1) from below during operation in a current supplying manner.

(Figure 2a)

Cathode for electrolytic cells

The invention relates to a cathode for an electrolytic cell for extracting aluminium by fused-salt electrolysis.

The Hall-Héroult process is currently used for the industrial extraction of aluminium from its oxide. This is an electrolytic process in which aluminium oxide (Al_2O_3) is dissolved in molten cryolite (Na_3 [AlF_6]) and the resulting mixture acts as a liquid electrolyte in an electrolytic cell. In principal, the design of this sort of electrolytic cell used to carry out the Hall-Héroult process is depicted schematically in Figures 1a to 1c, wherein Figure 1a shows a cross-section through a traditional cell, while Figure 1b shows an external side view of the cell. Fig. 1c shows a perspective view of an electrolytic cell.

Reference symbol 1 denotes a cathode, which may, for example, be made from graphite, anthracite or a mixture of these. Alternatively, coke-based graphitised cathodes may also be used. The cathode 1 is generally embedded in a mounting 2 made from steel and/or a fire-resistant material or the like. The cathode 1 may be made in one-piece as well as may be made from individual cathode blocks.

Over the entire length of the cell, a number of current supply bars 3 are introduced into the cathode 1, although only a single current supply bar 3 can be seen in the cross-sectional view in Figure 1a. It can be seen in Fig. 1c that two current supply bars, for example, may be provided for each cathode block. The current supply bars are used to supply the cell with the current required for the electrolytic process. There is a plurality of typically prismatic anodes 4 opposite the cathode 1, wherein two anodes 4 are schematically depicted in Figure 1a. Fig. 1c shows a detailed configuration of anodes in an electrolytic cell. During the performance of the process, the aluminium oxide dissolved in cryolite is split into aluminium ions and oxygen ions by applying a voltage between the cathode 1 and the anodes 4, in which case the aluminium ions move to the molten aluminium – actually the cathode from an electrochemical point of view – where they accept electrons. Due to the greater density, aluminium 5 gathers in the liquid phase beneath the melt 6 of aluminium oxide and cryolite. The oxygen ions are reduced to oxygen at the anode, said oxygen reacting with the carbon of the anodes.

Reference symbols 7 and 8 are the schematic representations of the negative and positive poles, respectively, of a voltage source for providing the voltage required for the electrolytic process, the value of which lies between approximately 3.5 and 5 V.

As can be seen in the side view in Figure 1b, the mounting 2 and therefore the entire electrolytic cell has an elongated form, in which a plurality of current-carrying bars 3 are conducted vertically through the side walls of the mounting 2. The longitudinal expansion of cells currently in use is typically between approximately 8 and 15 m, while the width expansion is approximately 3 to 4 m. A cathode, as is shown here in Figure 1a, is disclosed in EP 1845174, for example.

The high binding energy between aluminium and oxygen and also the heat and resistance losses cause a high energy requirement when producing aluminium by fused-salt electrolysis. The associated energy costs constitute a main part of the process costs. Reducing these costs is one of the major problems that need to be overcome in the field of fused-salt electrolysis.

One factor regarding low energy efficiency are the current supply bars already mentioned, which – amongst others - are traditionally made from steel on account of the high temperatures occurring during the fused-salt electrolysis. Compared with other electrical conductors, which can be used in other technical applications at low temperatures, such as aluminium and copper, steel nevertheless has a higher specific electrical resistance. Furthermore, the traditionally lateral horizontal electrical current supply via the current-supplying bars causes an uneven current distribution in the cathode.

Moreover, in the state of the art the different thermal coefficients of expansion of the cathode and current-supplying bars can lead to problems when starting and operating the electrolytic cell, particularly if the different thermal coefficients of expansion are not taken into account by taking suitable measures when contact is being made, the so-called "pouring" with liquid cast iron.

One problem addressed by the invention is to specify a cathode for an electrolytic cell used to extract aluminium, which allows the problems of the state of the art described above to be overcome, which allows energy efficiency in particular to be increased compared with traditional electrolytic cells and which allows, at the same time, a more uniform cathodic current density distribution to be achieved.

This problem is solved according to the invention by a cathode with the features of claim 1. Preferred embodiments are specified in the dependent claims.

A cathode for an electrolytic cell used to extract aluminium from its oxide having an underside is provided with a multiplicity of pins for a current supply in accordance with embodiments of the invention, wherein the pins contact the underside of the cathode from below during operation in a current-supplying manner

Within the meaning of the invention, the term 'cathode' is interpreted quite generally. It may be, for example (although not exclusively), a so-called cathode bottom, which is made from a plurality of cathode blocks, so that the core aspects according to the invention – namely, the contacting of the underside of the cathode from below with a multiplicity of pins in a current supplying manner as described above – are realised as a whole by this cathode bottom. However, the term cathode is also intended to refer to the partial structures forming such a cathode bottom, as in cathode blocks. All features that may contribute to the invention in connection with a "cathode" do so in the same way in connection with a "cathode block", without this having to be expressly explained below in each case.

In contrast with the state of the art, a current supply to the cathode is realised from below via pins. By means of the number of pins from below the current supply to the cathode may be designed much more uniform than has been possible so far via a small number of current-supplying bars into the cathode from the side.

Where the underside of the cathode is flat, for example, this sort of uniform current distribution may for example acquire a particularly uniform characteristic by designing and arranging the pins according to the desired current flow (e.g. by cross section). For example, the pins may be disposed regularly and/or at even intervals relative to the adjacent pins in each case. However, pins may also be selectively arranged according to templates or distribution diagrams, so as to counteract an inhomogeneous current distribution in the cathode. This may be advantageous in peripheral areas of the cathode, for example.

In addition, this sort of arrangement having a number of pins also allows a reduced wave formation to be achieved in the liquid aluminium that accumulates on the cathode during the performance of the fused-salt electrolysis process. The reason for this is that this wave formation, as is known, is generated by horizontal flows in the liquid aluminium caused by an inhomogeneous cathodic current distribution and the interaction thereof with the magnetic field. This undesired interaction can be reduced or minimised via the electrical and magnetic design achieved by means of the cross-section, number and distribution of the pins.

According to a preferred embodiment, at least one of the pins, particularly all pins, makes contact with the underside at an angle of under 30° to the perpendicular of the underside, particularly essentially vertical. An arrangement of this kind can be performed particularly easily from a technical viewpoint and therefore cost-effectively and is particularly uncomplicated in relation to the load distribution and mechanical arrangement of the pins.

In an advantageous embodiment of the cathode, the pins lead into the cathode. This means that one end of the pin concerned facing the cathode or its underside is partially located within the cathode in a mounted state. An especially good electrical contact between the pin and the cathode is thereby achieved.

Alternatively, however, other contact variants are conceivable, which are likewise included in the invention. This may, for example, involve an arrangement in which the cathode rests on the pins, in which case the pins do not lead into the cathode. In this case, the electrical contact between the pin and the underside of the cathode can be improved by carbonaceous or metallic compounds, such as carbonised pitch, electrically conductive adhesives or carbon compounds.

In accordance with a particularly preferred embodiment of the invention, the pins are inserted into the underside of the cathode by a screw connection. This enables the pins to be pre-assembled in the cathode, for example, before the cathode is installed in an electrolytic cell. Furthermore, a particularly secure hold and, where necessary, uncomplicated removal for maintenance or replacement are ensured.

Particularly advantageously, the screw connection is formed by a thread on one end of the pin, which faces the underside of the cathode, and a mating-thread in the underside of the cathode. As no additional screwing devices are required for this variant, but the pin itself being a screwing device, a particularly uncomplicated and material-saving screwing device is created.

The geometry of grub screws of this kind may advantageously match the geometry of threaded nipples for graphite electrodes used in electric steel production. This geometry has proved to be particularly good in terms of current distribution, mechanical strength and screwability.

It is particularly beneficial from a thermal and electrical viewpoint for grub screws to be made from the same material as the cathode. Mechanical stresses and contact resistances are thereby minimised.

In accordance with a preferred embodiment, the pins are made from graphite. This enables a high thermal stability of the pins and low electrical resistance to be achieved, which leads to an improved energy efficiency during the performance of the fused-salt electrolysis.

The longer the pins, the further the current bars that supply them with current are away from the cathode and therefore from the area of high process temperatures. As the distance increases, the strength of the electromagnetic fields caused by the current flow within the solid current bars also drops, which in turn favours avoidance of the already mentioned wave formation in the aluminium melt. It has proved to be particularly suitable in this respect for the pins to be between approximately 100 mm and 500 mm long.

A possible way of influencing the current distribution in the cathode is the choice of pin cross-section. On the one hand, the current distribution becomes more uniform the greater the number of pins used and the thinner these pins are. However, a lower limit is defined by the cost and input involved in using a multiplicity of pins. In practice, pins with a diameter between approximately 30 mm and 200 mm have proved to be particularly suitable in this respect. It should be noted in this regard that the individual choice must be adapted to the particular design features of the cathode form involved in each case, so that it may be advantageous, where appropriate, to use pins with different dimensions too.

As already mentioned, one advantage of a cathode according to the embodiments of the invention is that it enables the current supply to the cathode to be influenced in terms of a greater uniformity. One means of achieving this is by placing the pins as close together as possible. It has proved to be particularly beneficial, for example, if there are between approximately 4 and approximately 100 pins per square metre of base wall of the cathode.

In order to connect the pins to a voltage source, in one embodiment several pins in each case are connected to a common current bar at their end facing away from the cathode across a screw or clamp connection, for example. Consequently, as already mentioned, the current bars are spaced at a distance from the cathode that matches the length of the pins without a thread. It is important to ensure in this case that due to the thermal expansion of the current bar material (metal), the screw connection must be designed in such a way that no excessive mechanical forces act on the pins. This sort of metallic screw connection between a pin and a current bar can easily be realised by a person skilled in the art of joining techniques, which is why no further details of this will be given here.

Since with a cathode according to one embodiment of the invention, the current bars are spaced from the cathode itself, it is not necessary that the current bars are made from a particularly thermally stable material. The current bars must not therefore be made from iron, steel or the like. Instead, the common current bar may be made from a material containing more than 50% copper or aluminium. Both copper and aluminium exhibit a lower specific electrical resistance than iron or steel, so that the energy efficiency in the fused-salt electrolysis can be increased. The current bars may naturally also be made from pure copper or pure aluminium or from only slightly alloyed copper or aluminium. If, for example, a copper bar is used as a current bar, the specific electrical resistance can be reduced to approximately a quarter compared with the steel previously used.

In accordance with a further embodiment, the underside of the cathode is designed in the form of a trapezoidal body tapering downwards. In this way, the current introduced from below is introduced uniformly and evenly into the cathode. Where the cathode is made from individual cathode blocks, at least some of the cathode blocks of the cathode preferably have this sort of trapezoidal, downward-tapering body, in which case these bodies advantageously extend parallel to one another. The trapezoidal bodies may, for example, run longitudinally to the cathode or perpendicular to it.

In this way, the distance between the hot cathode tank or cathode and the current bar can be further increased, so that significantly lower temperatures prevail at the current bar site during operation than close to the cathode tank.

The invention is now described in greater detail with reference to the attached drawing using a non-restrictive exemplary embodiment. In the drawing:

Fig. 1a shows a cross section of an electrolytic cell for the extraction of aluminium oxide according to the state of the art;

Fig. 1b shows the electrolytic cell from Fig. 1a in an external longitudinal view;

Fig. 1c shows a perspective view, partially in section, of an electrolytic cell for the extraction of aluminium from aluminium oxide according to the state of the art;

Fig. 2a shows a perspective view of a cathode according to an embodiment of the invention;

Fig. 2b shows a representation of the cathode in Fig. 2a from a 90° rotated perspective and

Fig. 3 shows a sectional view of a screw connection of an electrolytic cell according to the invention.

The same reference symbols are used in the figures to refer to the same or corresponding elements in the different representations.

With reference to Figures 2a and 2b, an electrolytic cell with an embodiment of a cathode according to the invention is shown from different perspectives in each case. The cathode shown is suitable for use in the extraction of aluminium from aluminium oxide using the Hall-Héroult process. Side walls 1a are disposed on cathode 1. The side walls 1a may be i formed with the cathode 1 in one-piece or may be connected to it and extend along the longitudinal side of cathode 1 in the case shown. In this example the side walls 1a are made up of individual side wall blocks 1a1. Likewise, in this example the cathode 1 is made up of individual cathode blocks 1b1.

The side walls 1a and the cathode 1 delimit a tank 1c, in which the liquid electrolyte as well as the aluminium melt produced is held during a fused-salt electrolysis process. As can be seen in the figures, the underside 1g of the cathode 1 is trapezoidal in the form of downward-tapering bodies 1d, which extend parallel to one another along the width b of the cathode. Here, the trapezoidal bodies are designed flat at the bottom. In a base section of the trapezoidal bodies 1d, pins 1e are secured in the latter. In this exemplary embodiment, the pins are formed as grub screws similar to threaded nipples to connect graphite electrodes for electric steel production, as is schematically shown in Fig. 3.

In an alternative embodiment, different connecting means may also be chosen, however, such as a clamping connection, for example.

The grub screws 1e have a circular cross-section in this case, which is advantageous from the point of view of current density uniformity. As can be seen from Fig. 2b, the pins 1e are distributed in a slightly zig-zag formation, for example. It must be noted that although a form of cathode 1 with trapezoidal bodies 1d on its underside is depicted here, this configuration is not obligatory. Instead, the underside 1g of the cathode 1 may be designed flat, just as the upper side of the cathode 1. In this kind of embodiment, the pins 1e may be disposed in any form on the underside.

As shown in Fig. 2a, the pins may also be disposed in a line, for example. Of the pins disposed linearly in this way, a multiplicity may of course also be disposed parallel to one another.

All pins 1e in each case, which are disposed along a trapezoidal body 1d, are connected at their undersides, i.e. at the sides facing away from the cathode 1, to a common current bar 3, in turn by a screw connection, for example. A possible screw connection of a pin 1e to the current bar 3 is shown in Fig. 3. In this case, two screws are inserted from the side of the current bar 3 into the underside of a pin 1e.

Since the current bar 3 is spaced away from the tank 1c of the cathode 1, as can be seen in the figures, and therefore from the high-temperature area during operation, the temperature to which the current bar 3 must be resistant is very much lower than those temperatures prevailing at the current bars in the state-of-the-art embodiments according to Figures 1a to 1c. In other words, the current bars 3 are removed from the high-temperature zone in this case and can therefore be produced from a material that is less temperature-resistant but more electrically conductive than steel, for example.

In this exemplary embodiment, the current bars 3 are made from an aluminium alloy. Alternatively, known copper alloys can be used. The trapezoidal bodies 1d shown also have the effect of increasing the distance between the tank 1c of the cathode 1 and the current bars 3.

A possibly excessive dissipation of heat in metals that are not only electrically conductive, but also highly thermally conductive, may preferably be counteracted by a suitable layout, particularly a geometric layout.

As can be seen in the figures, several current bars 3 (in this case, three current bars 3 in each case) are each connected to a common busbar 10, which leads to a voltage source (not shown). Busbar 10 and current bars 3 may be made from the same materials, for example. In an alternative, a one-piece embodiment is also possible.

Depending on how the underside of the cathode 1 is designed, various configurations are possible for the pins 1e. If the underside is flat in design, the pins 1e may be secured to the underside in the form of a regular grid, for example. This is particularly favourable with regard to the already mentioned uniformity of the current supply.

In relation to cathode materials, any materials known to the person skilled in the art and suitable for the electrolysis of aluminium from aluminium oxide may be used. Suitable materials are specified in DE 10261745, for example, the content of which, in this respect, is to be incorporated here by reference. The pins 1e, in particular, may be made from the same materials as the cathode 1. Graphite has proved to be particularly favourable in this respect, due to its temperature resistance and due to its low specific electrical resistance.

Reference list

1	Cathode
1b1	Cathode block
1a	Side wall
1a1	Side wall block
1c	Tank
1d	Trapezoidal body
1e	Pin
1g	Cathode underside
2	Mounting
3	Current bar
4	Anode
5	Aluminium
6	Mixture (aluminium oxide, cryolite)
7	Negative pole, voltage source
8	Positive pole, voltage source
10	Busbar

Patent claims

1. A cathode (1) for an electrolytic cell used to extract aluminium from its oxide, exhibiting an underside (1g), characterised in that the cathode (1) is provided with a number of pins (1f) for a current supply, wherein the pins contact the underside (1g) of the cathode (1) from below during operation in a current supplying manner

2. The cathode (1) according to claim 1, characterised in that at least one of the pins makes contact with the underside (1g) at an angle of under 30° to the perpendicular of the underside (1g), particularly at least essentially vertical to the underside (1g).

3. The cathode (1) according to claim 1 or 2, characterised in that the pins (1f) lead into the cathode (1).

4. The cathode (1) according to one or more of the preceding claims characterised in that the pins (1f) are inserted into the underside (1g) of the cathode (1) by a screw connection.

5. The cathode (1) according to claim 4, characterised in that the screw connection is formed by a thread on one end of the pin (1f), which faces the underside (1g), and a mating-thread in the underside (1g) of the cathode (1).

6. The cathode (1) according to one or more of the preceding claims characterised in that the pins are made from graphite.

7. The cathode (1) according to one or more of the preceding claims characterised in that the pins are between approximately 100 mm and 500 mm long.

8. The cathode (1) according to one or more of the preceding claims characterised in that the pins (1f) exhibit a diameter of between approximately 30 mm and 200 mm.

9. The cathode (1) according to one or more of the preceding claims characterised in that there are between approximately 4 and approximately 100 pins (1f) per square metre of cathode (1).

10. The cathode (1) according to one or more of the preceding claims characterised in that several pins (1f) in each case are connected to a current bar (3) at their end facing away from the cathode (1).

11. The cathode (1) according to claim 8, characterised in that the current bar (3) is made from a material containing more than 50 % copper and/or aluminium.

12. The cathode (1) according to one or more of the preceding claims, characterised in that the underside (1g) of the cathode (1) is designed trapezoidally in the form of a trapezoidal bodies tapering downwards (1d).

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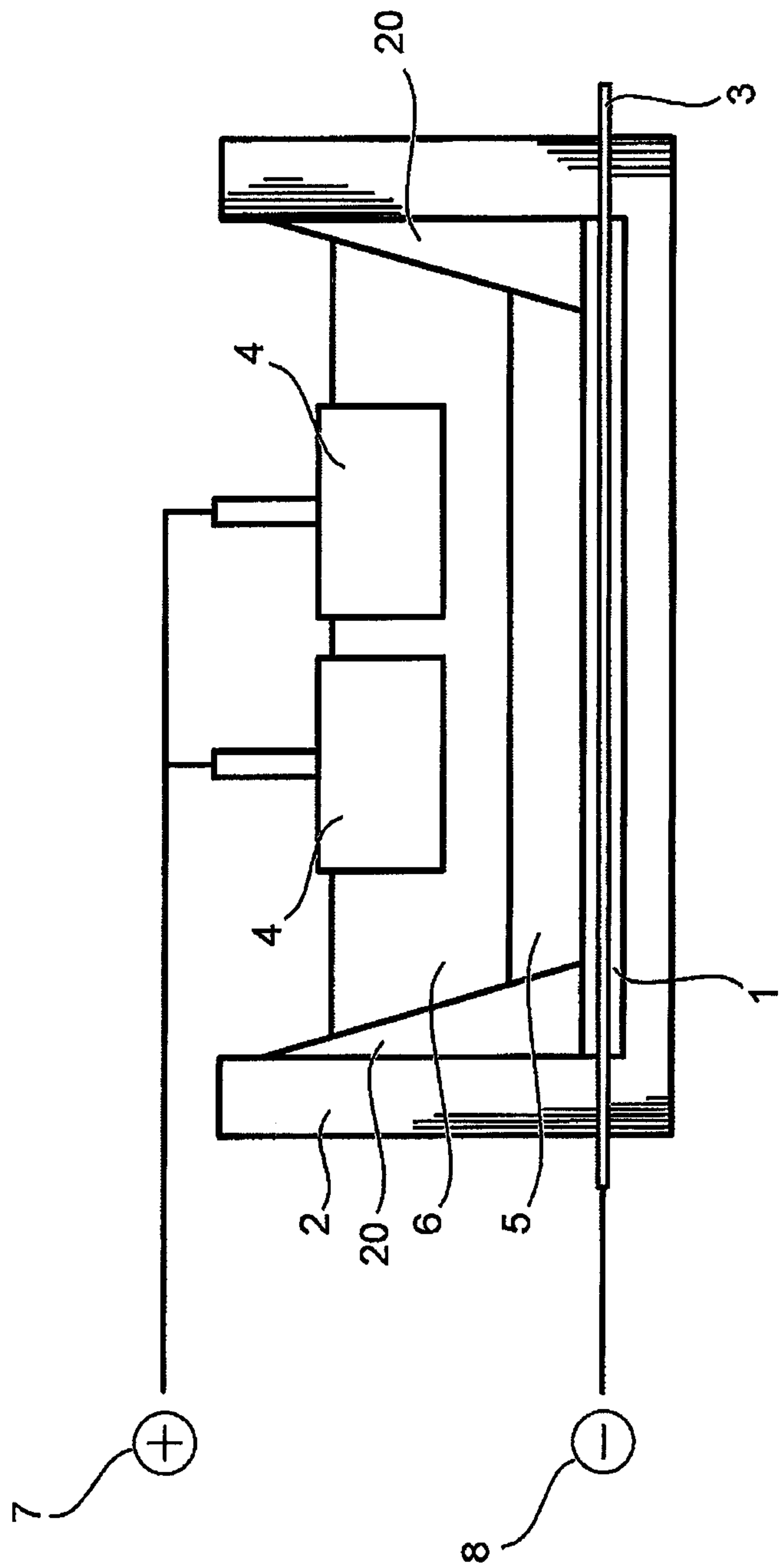

FIG. 1a

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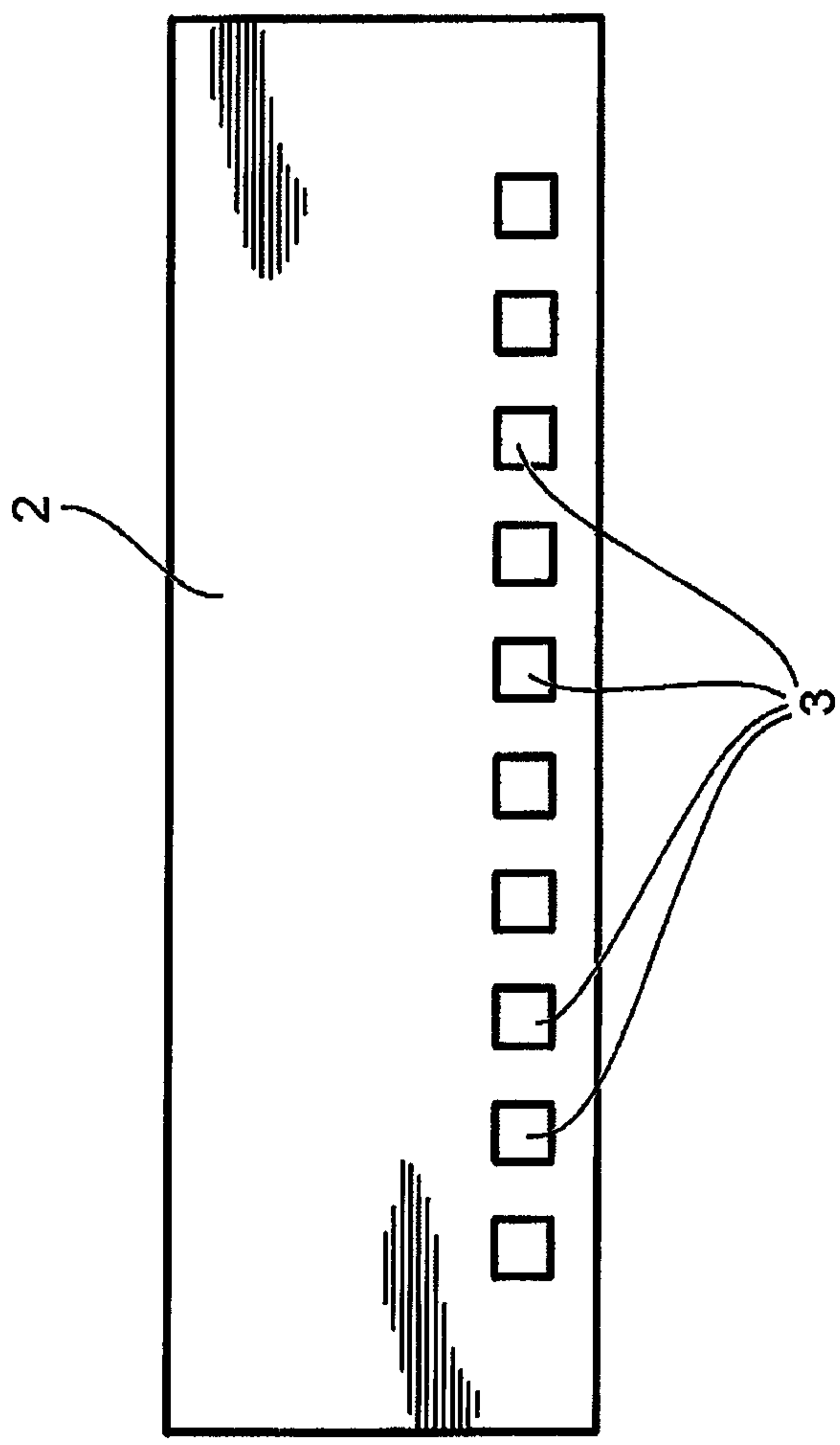

FIG. 1b

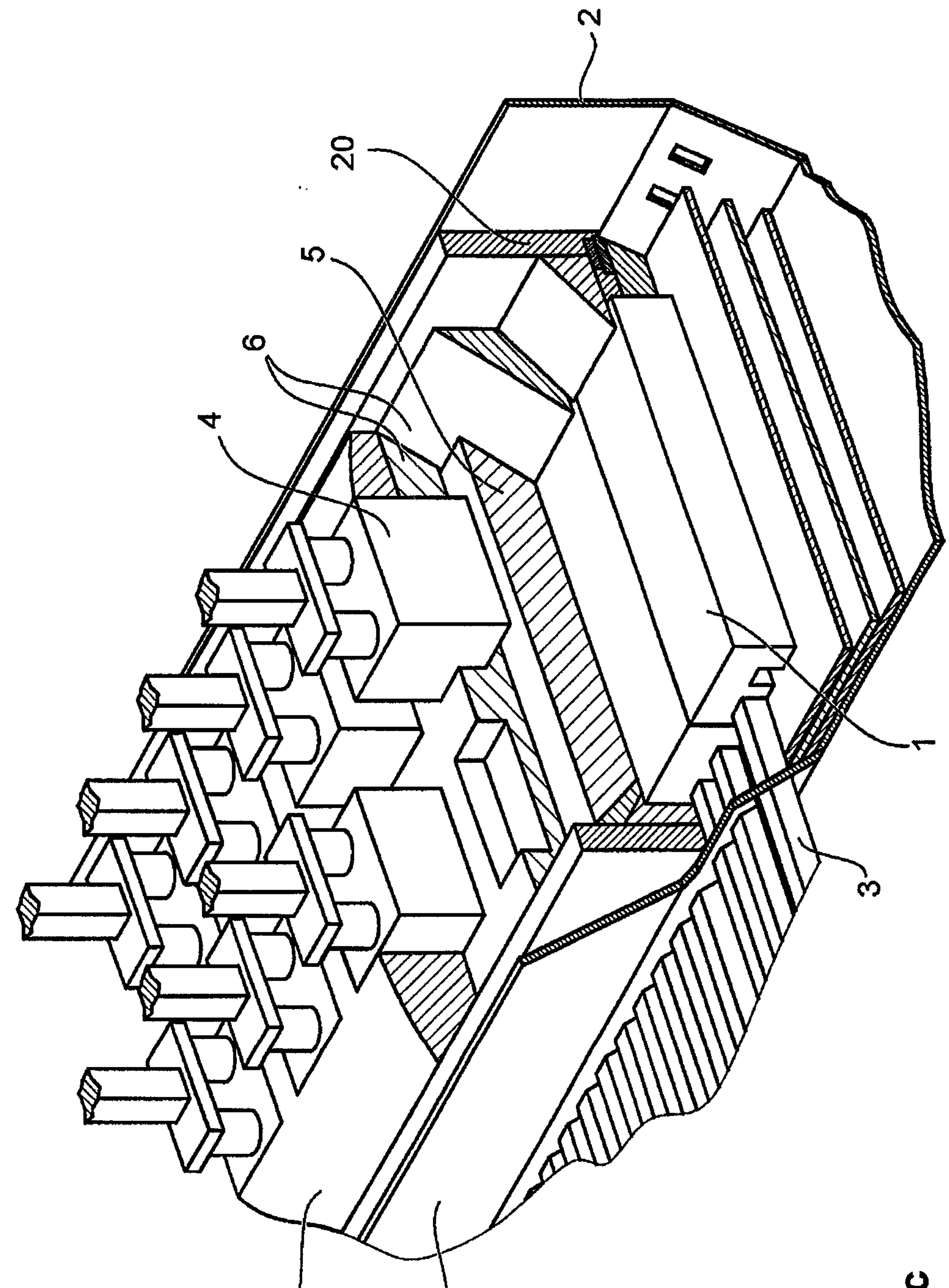

FIG. 1c

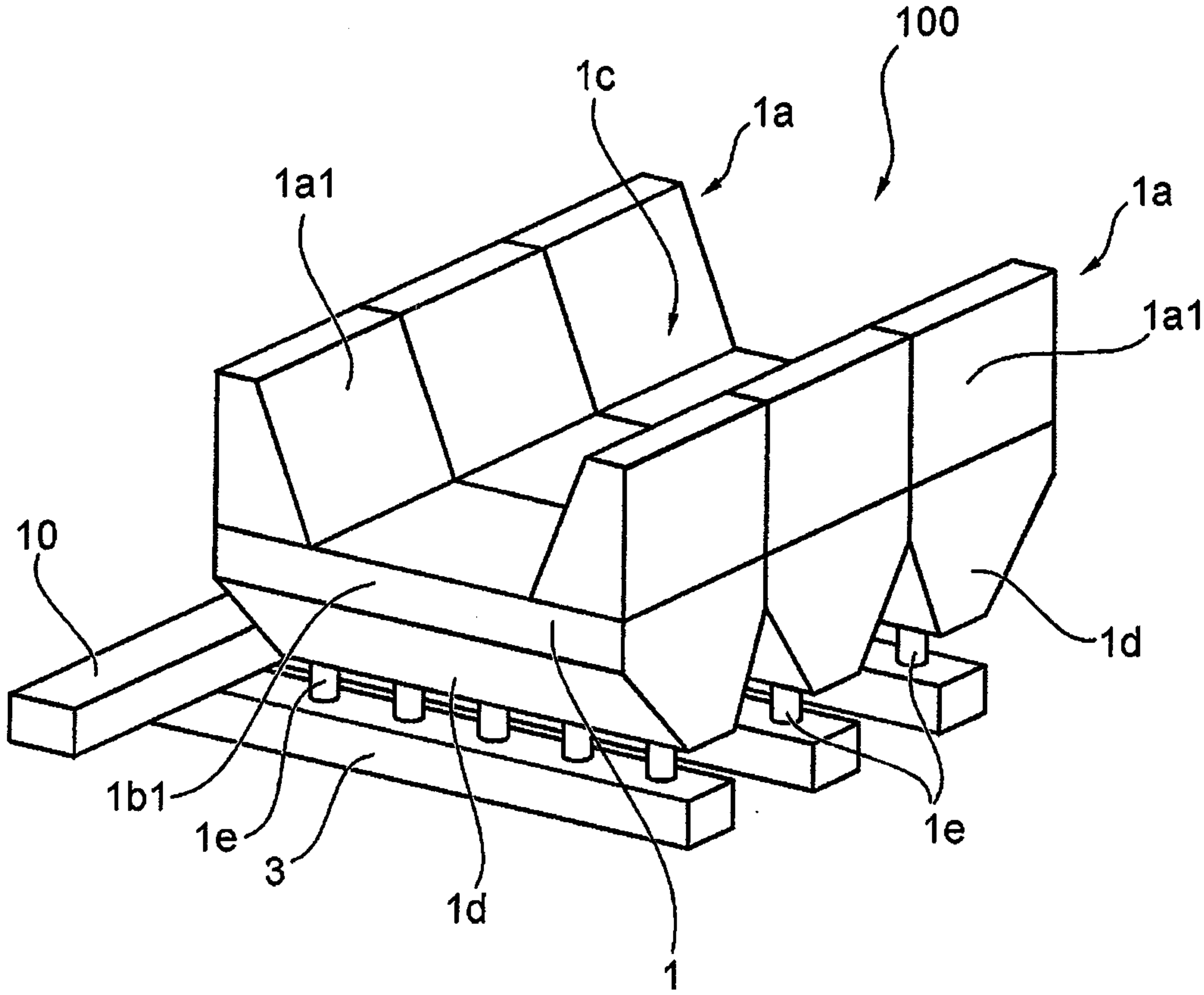

FIG. 2a

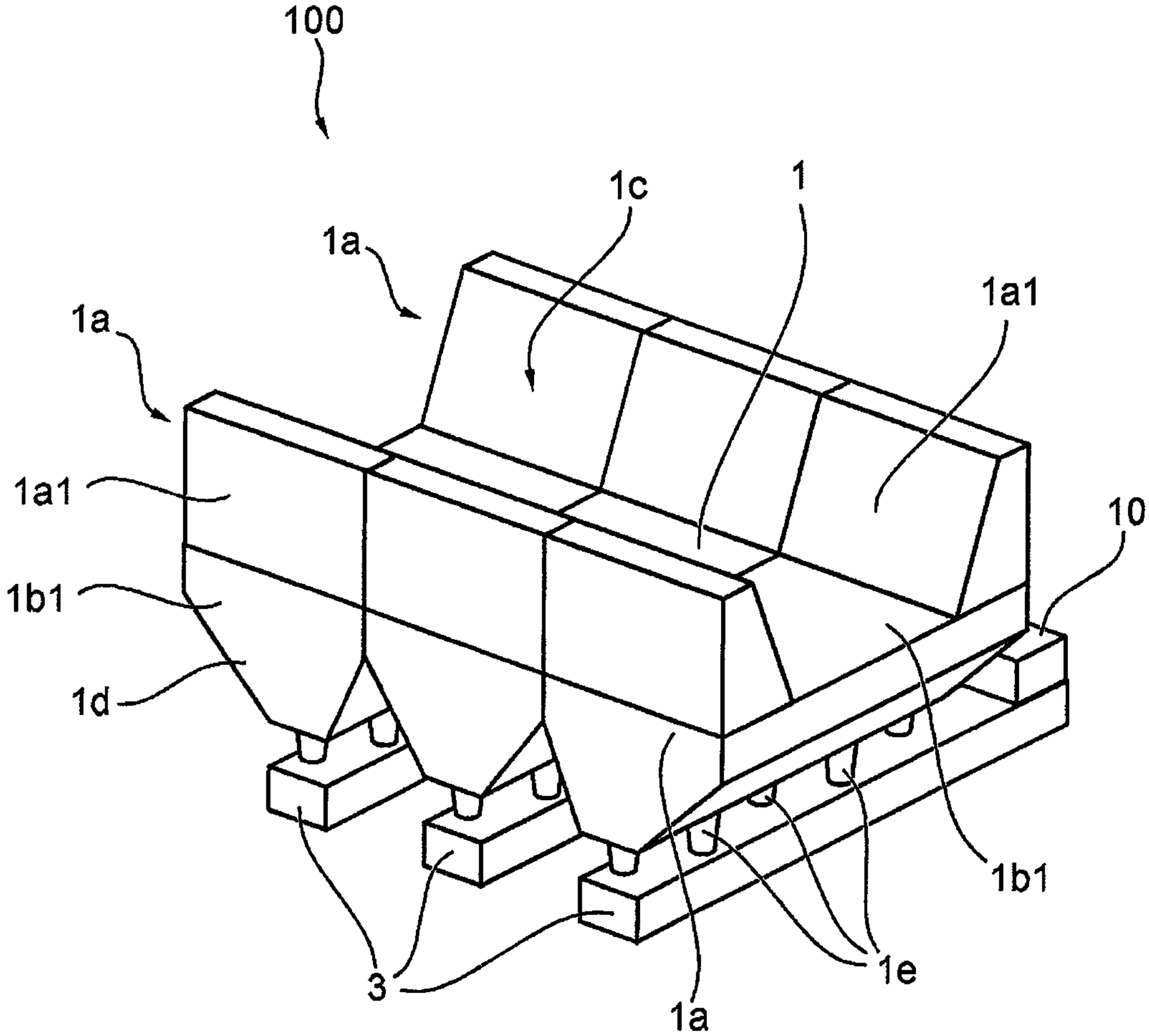

FIG. 2b

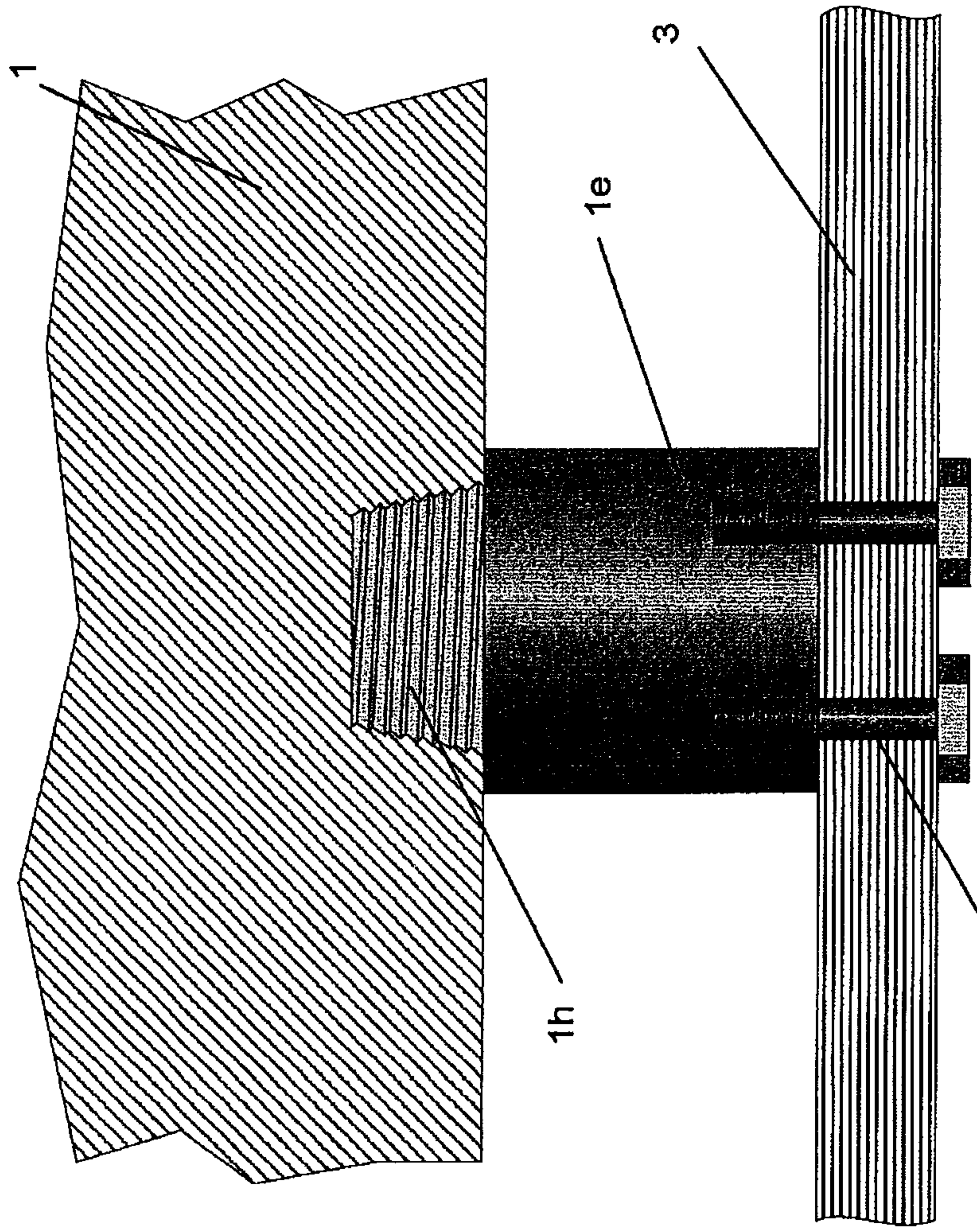

Fig. 3

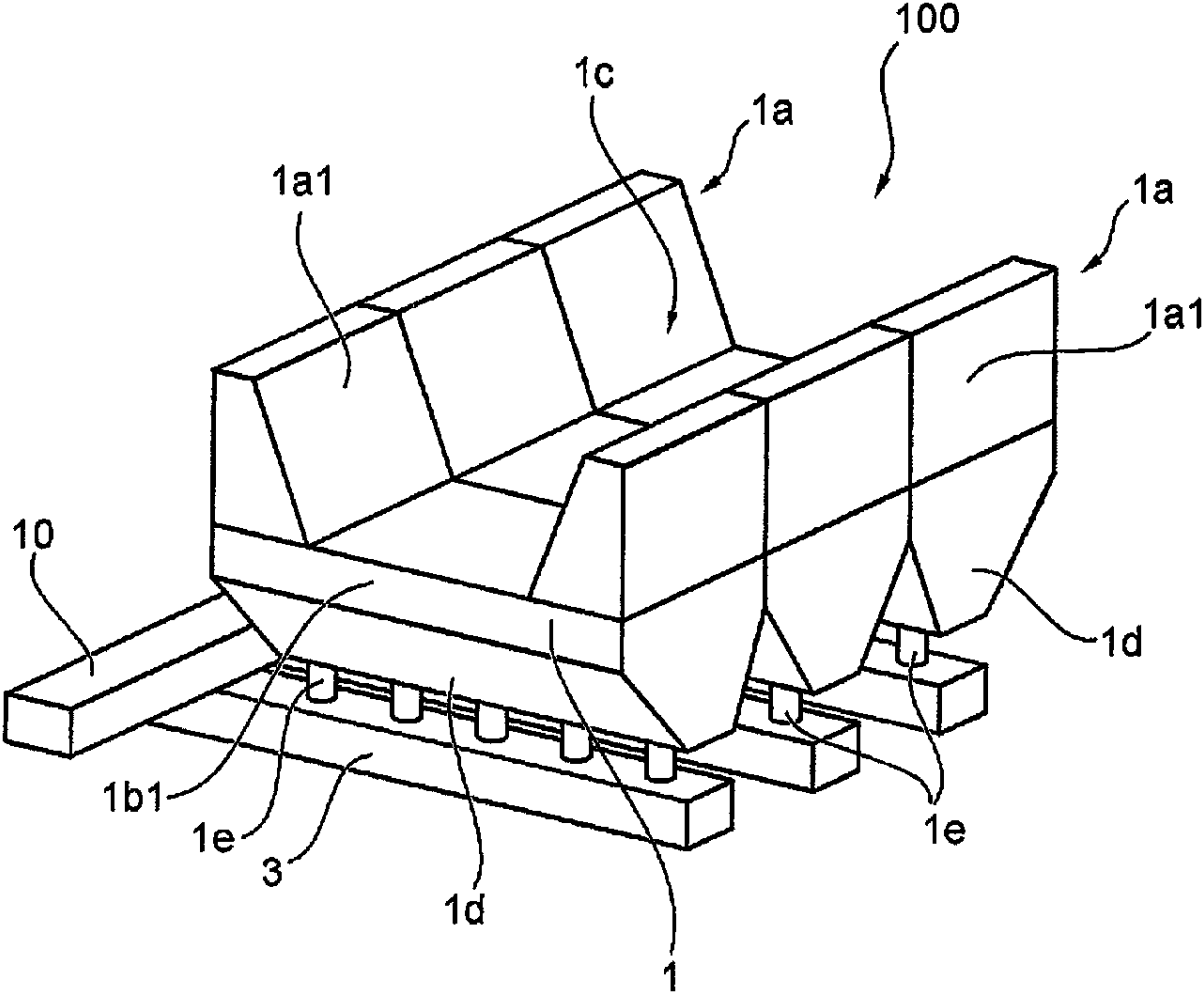

FIG. 2a