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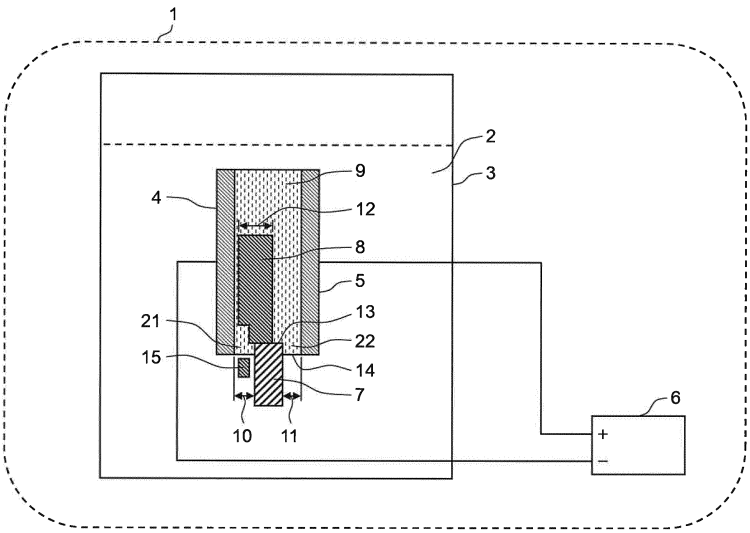
(54) PLATE-SHAPED ARTICLE DISASSEMBLING DEVICE

(57) A plate-shaped article disassembling device (1) crushes a plate-shaped article (8) by using a pulsed discharge, in which an insulating plate (7) does not come into contact with a negative electrode (4) and a positive electrode (5) in a discharge gap (9), each of the shortest distance (10) between the negative electrode (4) and the insulating plate (7) and the shortest distance (11) between the positive electrode (5) and the insulating plate (7) is narrower than the maximum width of the plate-shaped article (8), respectively, and the upper surface (13) of the insulating plate is above the lower surface (14) of the discharge gap (9).

FIG. 1



EP 3 412 363 A1

Description

BACKGROUND

1. Technical Field

[0001] The present disclosure relates to a plate-shaped article disassembling device for disassembling a plate-shaped article by causing a pulsed power discharge in liquid.

2. Description of the Related Art

[0002] In order to recycle articles such as used household appliances, efficient disassembly is necessary. Among the articles, the plate-shaped article in which a plurality of materials are stacked often has interlayers that are strongly bonded, and the disassembling efficiency is poor. An example of the plate-shaped article in which the plurality of materials are stacked is a solar battery panel or the like.

[0003] In Japanese Patent Unexamined Publication No. 2005-161151, a method of performing crushing by the Hopkinson effect by preparing a plate-shaped body, disposing electrodes and a medium, setting the positions of the electrodes and the value of energy supplied for generating a discharge, and discharging so that breaking occurs mainly on the back side of the plate-shaped body.

[0004] FIG. 3 is a view for explaining a state in which delamination of an object to be crushed is performed by a crushing method using a plate-shaped article disassembling device of the related art disclosed in JP-A-2005-161151. In FIG. 3, between plate-shaped body 202 and coaxial electrode 201, jelly-like substance 203 as a medium is disposed. By discharging by using coaxial electrode 201, part of jelly-like substance 203 is gasified or plasmatized by rapid joule heating. Then, since part of jelly-like substance 203 expands due to gasification or the like, pressure wave 210 is generated in jelly-like substance 203. This pressure wave 210 is incident on surface 204 of plate-shaped body 202 with jelly-like substance 203 as a medium. Pressure wave 210 is a compression wave in the traveling direction of pressure wave 210. Then, pressure wave 210 incident on plate-shaped body 202 propagates inside plate-shaped body 202 from surface 204 side to back surface 205 side. Further, pressure wave 210 reaches back surface 205 side, and pressure wave 210 is reflected by back surface 205 which is a free surface. At this time, since the phase of the reflected pressure wave is inverted with respect to the phase of the pressure wave before reflection, the reflected pressure wave becomes a tensile wave. Therefore, layer 206 to be peeled, which is the outermost layer on the back side of plate-shaped body 202, is subjected to tensile stress by the reflected pressure wave. The value of a current flowing through coaxial electrode 201 and the position of coaxial electrode 201 with respect to plate-shaped body 202 are set so that the tensile stress put by the pressure wave in layer 206 to be peeled is higher than the breaking strength of the material constituting plate-shaped body 202. As a result, by this pressure wave, peeling portion 207, which is a part of layer 206 to be peeled of plate-shaped body 202, is peeled off from the back surface of plate-shaped body 202.

SUMMARY

[0005] According to an aspect of the present disclosure, there is provided a plate-shaped article disassembling device that crushes a plate-shaped article to be disassembled by using a pulsed discharge, including a container that is filled with liquid, a positive electrode and a negative electrode that are placed in the liquid of the container in parallel with each other and in a vertical direction, an insulating plate that is placed in parallel to the positive electrode and the negative electrode in the liquid of the container, and a pulsed power supply that applies a high voltage pulse between the positive electrode and the negative electrode, in which the insulating plate is disposed below a discharge gap formed between the positive electrode and the negative electrode, the insulating plate does not come into contact with the positive electrode and the negative electrode in the discharge gap, each of a distance between the positive electrode and the insulating plate and a distance between the negative electrode and the insulating plate is narrower than a width of the plate-shaped article, and the upper surface of the insulating plate is placed above the lower surface of the discharge gap.

[0006] As described above, in the aspect of the present disclosure, when the plate-shaped article is disassembled by the discharge in the liquid, since the plate-shaped article moves every time the plate-shaped article is discharged, it is possible to prevent the part of plate-shaped article from being disassembled locally by concentrating the discharge path of the pulsed discharge in one part. Since the discharge path is set to various parts of the plate-shaped article, there is no need to move the electrodes and/or plate-shaped article in order to change the peeling position.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

FIG. 1 is an overall schematic view of a plate-shaped article disassembling device using a pulsed power discharge according to an embodiment of the present disclosure;

FIG. 2 is an overall schematic view of the plate-shaped article disassembling device using a pulsed power discharge according to an embodiment of the present disclosure; and

FIG. 3 is a schematic view of a plate-shaped article disassembling device using a pulsed power discharge of the related art.

DETAILED DESCRIPTION

[0008] Prior to describing embodiments, problems in the related art will be briefly described.

[0009] In a case where the technique of the related art in FIG. 3 to recycling, there are a lot of restrictions on plate-shaped body 202 to be disassembled. In the related art, the value of a current flowing through coaxial electrode 201 and the position of coaxial electrode 201 with respect to plate-shaped body 202 need to be set so that the tensile stress put by the pressure wave 210 in layer 206 to be peeled is higher than the breaking strength of the material constituting plate-shaped body 202. In the case of disassembling the objects in the same form continuously, the technique of the related art is effective, but in the case of recycling, it is sometimes impossible to align the front and back of surface 204 and back surface 205 in some cases. In addition, one coaxial electrode 201 can peel off one part, and changing the peeling position has a problem that it is necessary to move coaxial electrode 201 or plate-shaped body 202. In a case where plate-shaped body 202 cannot be moved, it is necessary to move coaxial electrode 201, it takes time to move high-voltage coaxial electrode 201, and the efficiency of disassembling is poor.

[0010] Therefore, the object of the present disclosure is to solve the above problem and to provide an efficient plate-shaped article disassembling device that does not require aligning the front and back of the plate-shaped article and moving electrodes and/or the plate-shaped article for changing the peeling position.

[0011] Hereinafter, embodiments of the present disclosure will be described in detail with reference to drawings.

[0012] The plate-shaped article disassembling device according to embodiments of the present disclosure is a device that generates a pulsed discharge between electrodes standing in liquid and disassembles a plate-shaped article by using the discharge or a shock wave induced by the discharge.

Embodiment 1

[0013] FIG. 1 shows an embodiment of a plate-shaped article disassembling device according to Embodiment 1 of the present disclosure.

[0014] Plate-shaped article disassembling device 1 includes container 3 filled with liquid 2, negative electrode 4 and positive electrode 5, pulsed power supply 6, and insulating plate 7.

[0015] Container 3 is, for example, a rectangular parallelepiped container, but the shape thereof is not limited thereto. Container 3 is filled with liquid 2. In order to stably discharge from positive electrode 5 to negative electrode 4, it is preferable that the insulating property of liquid 2 is high, but tap water may be used. In the case of crushing an object to be processed without contamination of impurities, ion-exchanged water or pure water with low conductivity may be used.

[0016] Negative electrode 4 and positive electrode 5 are conductive plate-shaped members that face each other in a direction orthogonal to a vertical direction and are placed in parallel to each other along the vertical direction in liquid 2 of container 3.

[0017] In addition, insulating plate 7 is placed in parallel to negative electrode 4 and positive electrode 5 and placed below discharge gap 9 having, for example, a rectangular parallelepiped shape formed between the facing surfaces of negative electrode 4 and positive electrode 5 in liquid 2 of container 3.

[0018] Plate-shaped article 8 to be disassembled is disposed along the vertical direction of discharge gap 9 and disassembled. Examples of the plate-shaped article 8 are used home appliances and the like, specifically, a plate-shaped article in which a plurality of materials are stacked, more specifically, a solar battery panel, and the like can be mentioned.

[0019] In addition, insulating plate 7 does not comes into contact with negative electrode 4 and positive electrode 5 in discharge gap 9 and is placed such that each of shortest distance 10 between negative electrode 4 and insulating plate 7 and shortest distance 11 between positive electrode 5 and insulating plate 7 is narrower than maximum width 12 in the direction orthogonal to the vertical direction of plate-shaped article 8 to be disassembled.

[0020] In FIG. 1, upper surface 13 of insulating plate 7 is placed above lower surface 14 of discharge gap 9 between the lower end of negative electrode 4 and the lower end of positive electrode 5.

[0021] Since discharge gap 9 is partitioned by insulating plate 7, the lower surface of discharge gap 9 substantially below does not reach lower surface 14 but upper surface 13 of insulating plate 7.

[0022] Pulsed power supply 6 applies a high-voltage pulse between positive electrode 5 and negative electrode 4. For pulsed power supply 6, it is possible to use a Marx generator capable of applying any voltage up to 500 kV.

[0023] Plate-shaped article 8 to be disassembled is sandwiched between positive electrode 5 and negative electrode 4 and placed on upper surface 13 of insulating plate 7, whereby plate-shaped article 8 is disposed in discharge gap 9.

At this time, a downward moving force acts on plate-shaped article 8 by gravity, but positive electrode 5 and negative electrode 4 are placed along the vertical direction. Each of shortest distance 10 between negative electrode 4 and insulating plate 7 and shortest distance 11 between positive electrode 5 and insulating plate 7 is set narrower than maximum width 12 of plate-shaped article 8 to be disassembled. Thus, although plate-shaped article 8 enters first gap 21 between negative electrode 4 and insulating plate 7 or second gap 22 between positive electrode 5 and insulating plate 7, plate-shaped article 8 never falls below discharge gap 9 by gravity. In addition, when insulating plate 7 comes into contact with negative

electrode 4 and positive electrode 5 in discharge gap 9, since the probability of a discharge occurring in insulating plate 7 increases, it is necessary to place insulating plate 7 so that negative electrode 4 and positive electrode 5 do not come into contact with each other in discharge gap 9. Then, by applying a high-voltage pulse between positive electrode 5 and negative electrode 4 by using pulsed power supply 6, plate-shaped article 8 is disassembled by a discharge or a shock wave induced by the discharge. At this time, positive electrode 5, negative electrode 4, and insulating plate 7 are placed along the vertical direction, and insulating plate 7 does not come into contact with negative electrode 4 and positive electrode 5 in discharge gap 9. Since shortest distance 10 between negative electrode 4 and insulating plate 7 and shortest distance 11 between positive electrode 5 and insulating plate 7 are set to be narrower than maximum width 12 of plate-shaped article 8 to be disassembled, in a case where peeling portion 15 disassembled and peeled off from plate-shaped article 8 by a discharge is smaller than shortest distance 10 between negative electrode 4 and insulating plate 7 or shortest distance 11 between positive electrode 5 and insulating plate 7, the peeling portion falls downward from first gap 21 between negative electrode 4 and insulating plate 7 or second gap 22 between positive electrode 5 and insulating plate 7. That is, first gap 21 between negative electrode 4 and insulating plate 7, and second gap 22 between positive electrode 5 and insulating plate 7 have a sieving function. Thus, since loss due to excessive crushing of peeling portion 15 can be suppressed, plate-shaped article 8 can be efficiently disassembled. In addition, by a discharge or a shock wave induced by the discharge, plate-shaped article 8 moves every time plate-shaped article 8 is discharged. That is, the discharge has a vibration function necessary for sieving. In addition, since plate-shaped article 8 moves every time plate-shaped article 8 is discharged, it is possible to prevent the part of plate-shaped article 8 from being disassembled locally by concentrating the discharge path of the pulsed discharge in one part. Since the discharge path is set to various parts of plate-shaped article 8, it is possible to deal with various kinds of articles under one condition setting.

[0024] As described above, when disassembling plate-shaped article 8 by the discharge in liquid 2, since the discharge or a shock wave induced by the discharge and first gap 21 between negative electrode 4 and insulating plate 7 or second gap 22 between positive electrode 5 and insulating plate 7 have a sieving function, it is possible to suppress the loss due to excessive crushing of peeling portion 15 and to efficiently disassemble various kinds of plate-shaped articles. In addition, since insulating plate 7 is placed so that negative electrode 4 and positive electrode 5 do not come into contact with each other in discharge gap 9, the probability of a discharge occurring in insulating plate 7 decreases and it is possible to efficiently disassemble the article. In addition, since there is no dependency between the front and back of plate-shaped article 8 and the discharge phenomenon, there is no need to align the front and back of the plate-shaped article with respect to discharge gap 9. Further, since plate-shaped article 8 moves every time plate-shaped article 8 is discharged, it is possible to prevent the part of plate-shaped article 8 from being disassembled locally by concentrating the discharge path of the pulsed discharge in one part. Since the discharge path is set to various parts of plate-shaped article 8, there is no need to move the electrodes (negative electrode 4 and positive electrode 5) and/or plate-shaped article 8 in order to change the peeling position.

Embodiment 2

[0025] The plate-shaped article disassembling device according to Embodiment 2 of the present disclosure in FIG. 2 differs from the device in FIG. 1 in that electrically floating intermediate electrode 101 is added to an intermediate portion of the discharge gap between negative electrode 4 and positive electrode 5. That is, between negative electrode 4 and positive electrode 5, the discharge gap is divided into a plurality of, for example, discharge gaps 109 having a rectangular parallelepiped shape (first divided discharge gap according to the present disclosure) and divided discharge gaps 159 (second divided discharge gap according to the present disclosure) and includes at least one or more intermediate electrodes 101 that are disposed and electrically floating.

[0026] The insulating plate includes first insulating plate 107 placed in parallel to intermediate electrode 101 and negative electrode 4 in liquid 2 of container 3, and second insulating plate 157 placed in parallel between intermediate electrode 101 and positive electrode 5.

[0027] First insulating plate 107 is disposed below divided discharge gap 109 and does not come into contact with negative electrode 4 and intermediate electrode 101 in divided discharge gap 109 and each of shortest distance 110 between negative electrode 4 and first insulating plate 107 and shortest distance 111 between intermediate electrode 101 and first insulating plate 107 is narrower than maximum width 112 of plate-shaped article 108.

[0028] Second insulating plate 157 is disposed below divided discharge gap 159 and does not come into contact with positive electrode 5 and intermediate electrode 101 in divided discharge gap 159. Each of shortest distance 161 between positive electrode 5 and second insulating plate 157 and shortest distance 160 between intermediate electrode 101 and second insulating plate 157 is narrower than maximum width 162 of plate-shaped article 158, respectively.

[0029] Upper surface 113 of first insulating plate 107 is placed above lower surface 114 of divided discharge gap 109.

[0030] Upper surface 163 of second insulating plate 157 is placed above lower surface 164 of divided discharge gap 159.

[0031] As a result, the disposal relationships of first insulating plate 107 disposed between negative electrode 4 and intermediate electrode 101, plate-shaped article 108 disposed between negative electrode 4 and intermediate electrode 101, divided discharge gap 109 formed between negative electrode 4 and intermediate electrode 101, shortest distance 110 between negative electrode 4 and first insulating plate 107, shortest distance 111 between intermediate electrode 101 and first insulating plate 107, maximum width 112 of plate-shaped article 108, upper surface 113 of first insulating plate 107, and lower surface 114 of divided discharge gap 109 are equivalent to the respective disposal relationships described with reference to FIG. 1. In addition, the disposal relationships of second insulating plate 157 disposed between positive electrode 5 and intermediate electrode 101, plate-shaped article 158 disposed between positive electrode 5 and intermediate electrode 101, divided discharge gap 159 formed between positive electrode 5 and intermediate electrode 101, shortest distance 160 between intermediate electrode 101 and second insulating plate 157, shortest distance 161 between positive electrode 5 and second insulating plate 157, maximum width 162 of plate-shaped article 158, upper surface 163 of second insulating plate 157, and lower surface 164 of divided discharge gap 159 are equivalent to the respective disposal relationships described with reference to FIG. 1.

[0032] By applying a high-voltage pulse between positive electrode 5 and negative electrode 4 by using pulsed power supply 6 and discharging respectively through intermediate electrode 101 into divided discharge gap 109 and divided discharge gap 159, plate-shaped article 108 and plate-shaped article 158 are individually disassembled by the discharge or shock waves induced by the discharge. Therefore, in the configuration shown in FIG. 2, by disposing plate-shaped article 108 and plate-shaped article 158 in the two gaps between divided discharge gap 109 and divided discharge gap 159, respectively, it is possible to disassemble the plate-shaped articles separately using one pulsed power supply 6, thereby providing a device with high efficiency. In addition, although FIG. 2 illustrates the case where there is only one intermediate electrode 101, a plurality of intermediate electrodes 101 may be present. (The number of intermediate electrodes) + 1 is the number of discharge gaps.

[0033] By appropriately combining any embodiments or modification examples of the various embodiments or modifications, it is possible to achieve the respective effects of each. In addition, it is possible to combine the embodiments or to combine the examples or to combine the embodiments and the examples, and to combine the features in the different embodiments or examples.

[0034] The plate-shaped article disassembling device according to the above-described aspect of the present disclosure can efficiently disassemble a plate-shaped article in which a plurality of materials such as a solar cell panel are stacked. In a case where the layered materials are fixed with a resin, there is also a method of disassembling by dissolving the resin by an organic solvent or heating, but by using a pulsed discharge, it is possible to disassemble without dissolving the resin without using an organic solvent without heating. In the plate-shaped article disassembling device according to the above-described embodiment of the present disclosure, there is no need to move electrodes and/or a plate-shaped article, it is possible to improve efficiency and expect energy saving.

Claims

1. A plate-shaped article disassembling device that crushes a plate-shaped article to be disassembled by using a pulsed discharge, the device comprising:

   a container that is filled with liquid;
   a positive electrode and a negative electrode that are placed in the liquid of the container in parallel with each other and in a vertical direction;
   an insulating plate that is placed in parallel to the positive electrode and the negative electrode in the liquid of the container; and
   a pulsed power supply that applies a high voltage pulse between the positive electrode and the negative electrode,
   wherein the insulating plate is disposed below a discharge gap formed between the positive electrode and the negative electrode,
   the insulating plate does not come into contact with the positive electrode and the negative electrode in the discharge gap,
   each of a distance between the positive electrode and the insulating plate and a distance between the negative electrode and the insulating plate is narrower than a width of the plate-shaped article, and
   an upper surface of the insulating plate is placed above a lower surface of the discharge gap.

2. The plate-shaped article disassembling device of Claim 1, further comprising:

   an intermediate electrode that is disposed and electrically floating between the positive electrode and the negative electrode and divides the discharge gap into a first divided discharge gap and a second divided discharge gap,
   wherein the insulating plate includes a first insulating plate placed between the intermediate electrode and the negative electrode in parallel to the intermediate electrode and the negative electrode, and a second insulating plate placed between the intermediate electrode and the pos-

itive electrode in parallel to the intermediate electrode and the positive electrode, in the liquid of the container,
the first insulating plate is disposed below the first divided discharge gap,
the second insulating plate is disposed below the second divided discharge gap,
the first insulating plate does not come into contact with the intermediate electrode and the negative electrode in the first divided discharge gap,
the second insulating plate does not come into contact with the intermediate electrode and the positive electrode in the second divided discharge gap,
each of a distance between the intermediate electrode and the first insulating plate and a distance between the negative electrode and the first insulating plate is narrower than a width of the plate-shaped article,
each of a distance between the intermediate electrode and the second insulating plate and a distance between the positive electrode and the second insulating plate is narrower than a width of the plate-shaped article,
an upper surface of the first insulating plate is placed above a lower surface of the first divided discharge gap, and
an upper surface of the second insulating plate is placed above a lower surface of the second divided discharge gap.

FIG. 1

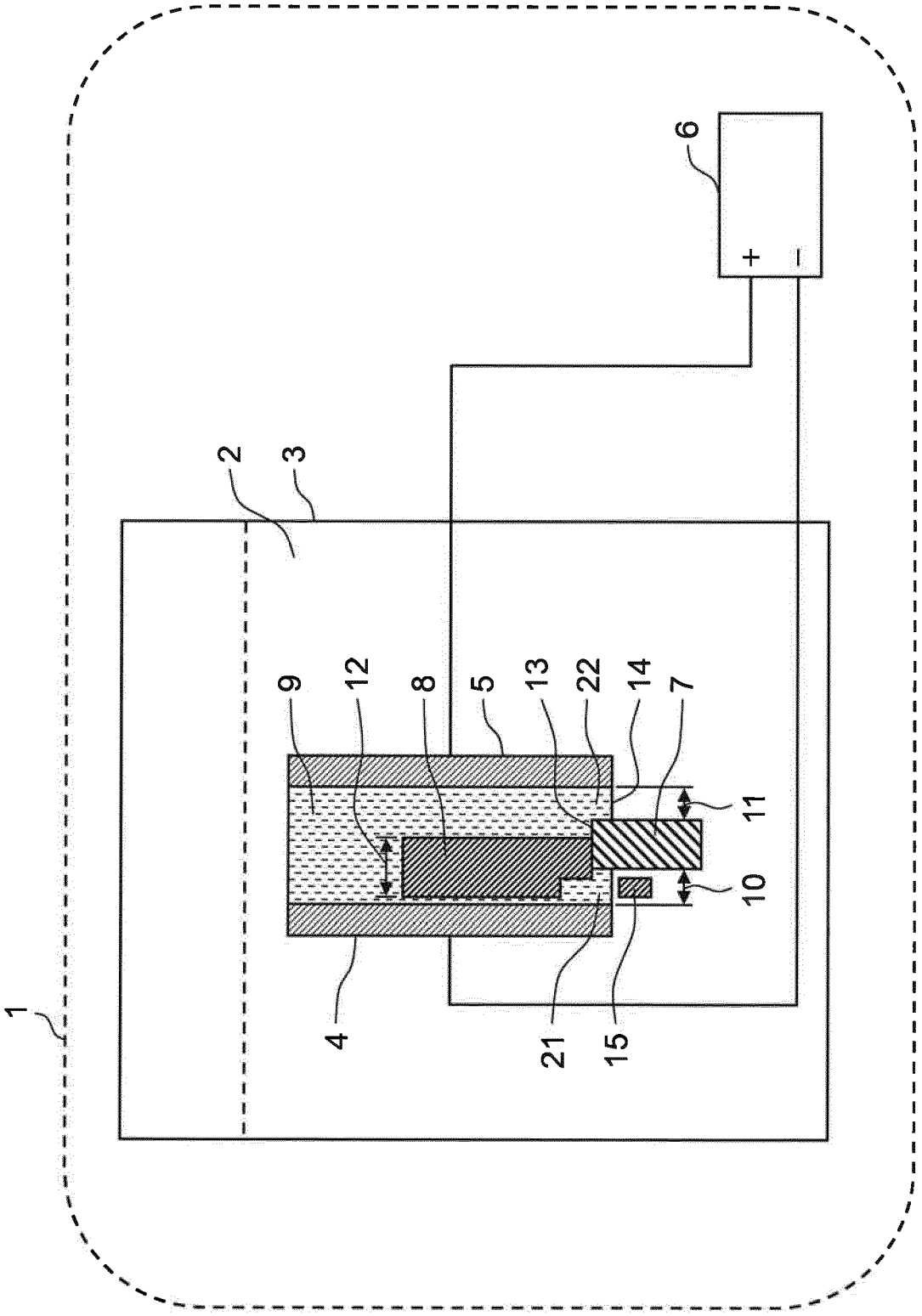


FIG. 2

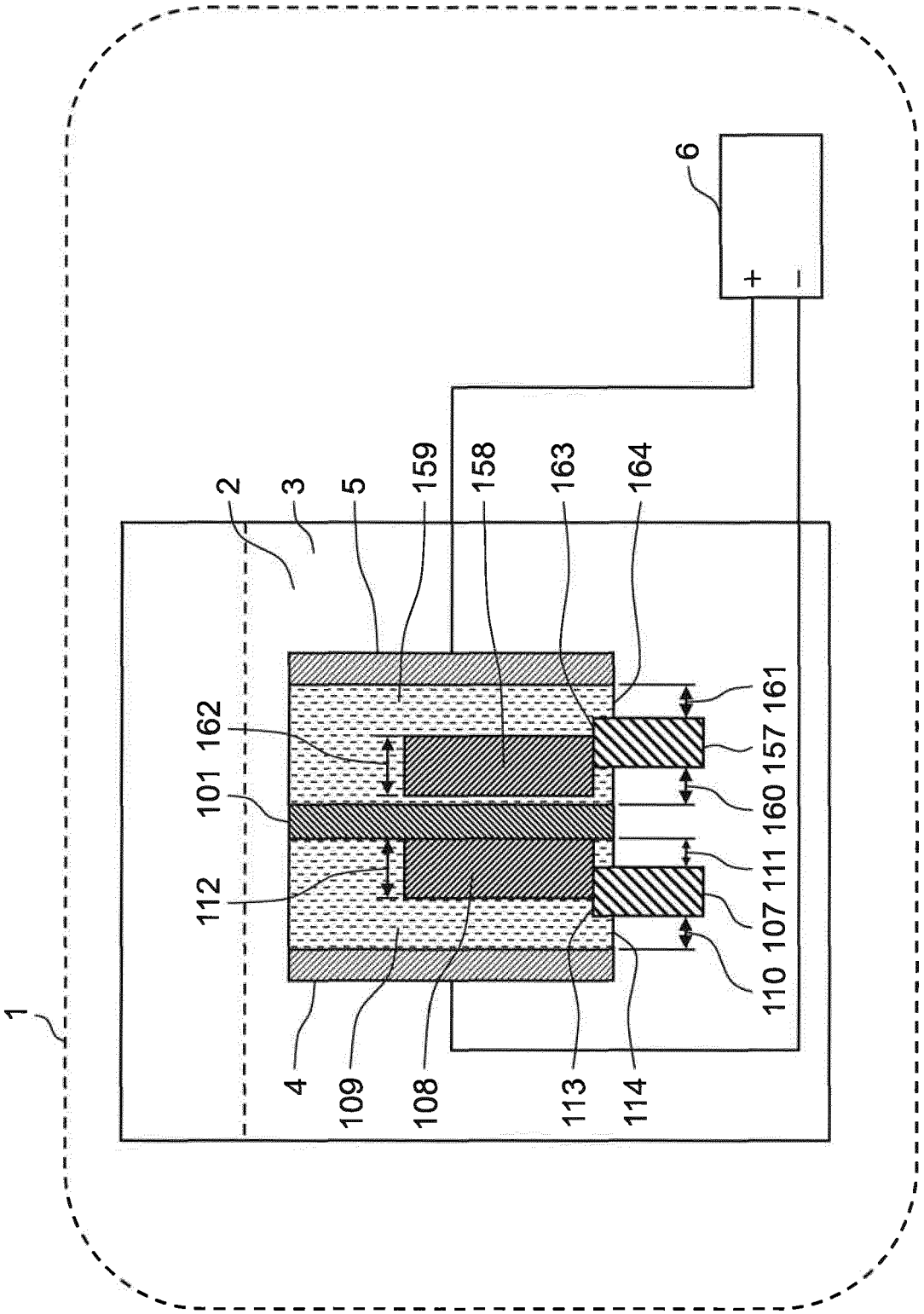

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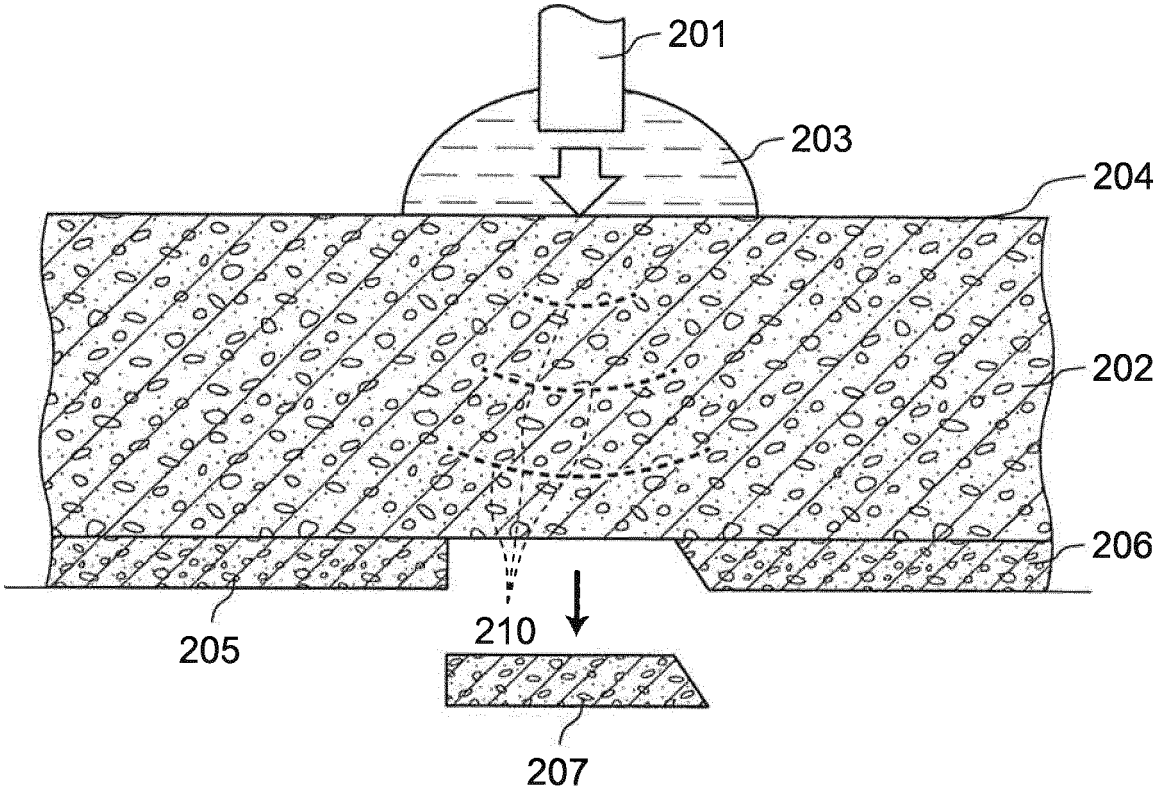
FIG. 3



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EUROPEAN SEARCH REPORT

Application Number
EP 18 16 4882

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A,D	JP 2005 161151 A (SUMITOMO ELECTRIC INDUSTRIES; OKUMURA ENGINEERING CORP) 23 June 2005 (2005-06-23) * claims; figures 1,4 *	1	INV. B02C19/18
A,P	JP 2017 136516 A (MITSUBISHI ELECTRIC CORP) 10 August 2017 (2017-08-10) * claims; figures *	1	

TECHNICAL FIELDS SEARCHED (IPC)

B02C
G10K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	12 October 2018	Leitner, Josef

CATEGORY OF CITED DOCUMENTS

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12-10-2018

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2005161151 A	23-06-2005	NONE	
JP 2017136516 A	10-08-2017	NONE	

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Patent documents cited in the description

- JP 2005161151 A **[0003] [0004]**