(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 929 333 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
29.12.2021 Bulletin 2021/52

(51) Int Cl.:
C25D 17/00 *(2006.01)*

(21) Application number: **20181936.4**

(22) Date of filing: **24.06.2020**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicants:
- **Shan, Ling-Pao**
  Zhubei City, Hsinchu County 302 (TW)
- **Huang, Chun-Kuei**
  Zhubei City, Hsinchu County 302 (TW)

(72) Inventors:
- **Shan, Ling-Pao**
  Zhubei City, Hsinchu County 302 (TW)
- **Huang, Chun-Kuei**
  Zhubei City, Hsinchu County 302 (TW)

(74) Representative: **Becker, Eberhard**
Becker & Kurig Partnerschaft
Patentanwälte PartmbB
Bavariastrasse 7
80336 München (DE)

(54) A NEW TYPE OF CATHODE ELECTRODE STRUCTURE FOR ELECTROPLATING EQUIPMENT

(57) A cathode electrode structure for a single-sided or double-sided horizontal type electroplating equipment is provided, which includes a conductive shaft connected to an electric source. A soft and flexible conductive layer tubular in shape is sheathed on the conductive shaft and the two ends of the conductive layer are provided with conductive terminals directly contacting the conductive shaft respectively, wherein the outer surface of the conductive layer forms a cathode electrically contacting an object to be plated and a cavity is formed between the inner surface of the conductive layer and the conductive shaft. A buffer cushion layer is disposed inside the cavity, and the outer surface and the inner surface of the buffer cushion layer press against the conductive shaft and the conductive layer. The new electrode structure can avoid that the fragile objects to be damaged due to clip type cathodes during electroplating process and increase the service life of the cathode.

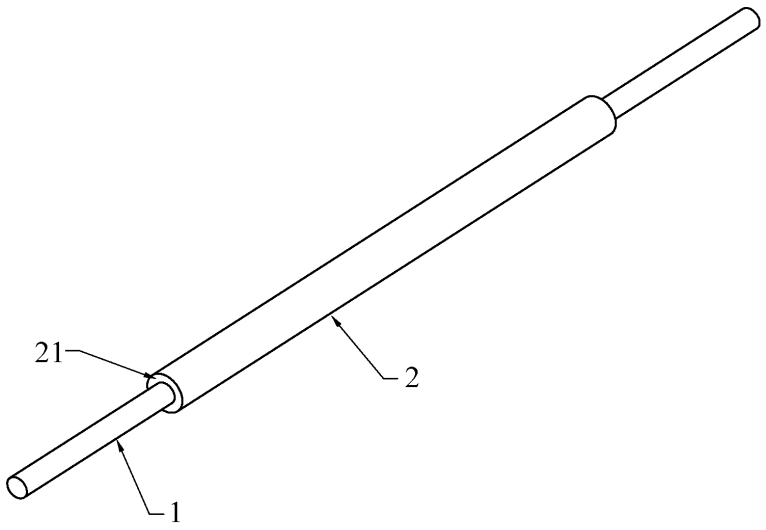

FIG. 1

EP 3 929 333 A1

Description

BACKGROUND OF THE INVENTION

1. Field of the invention

[0001] The present invention relates to an electroplating technique, in particular to an a cathode electrode structure of a single-sided or double-sided horizontal type electroplating equipment applicable for semiconductor chips, printed circuit boards and photovoltaic cells.

2. Description of the prior art

[0002] With expansion and swift development of the semiconductor industry, the printed circuit board industry and the photovoltaic cell industry and the governments of many countries adjust their policies. For the reason, the linewidths of semiconductor chips, printed circuit boards and photovoltaic cells are required to be thinner, and the costs thereof are also required to be lower. Thus, the objectives of many technologies are aimed to reduce the complexity and use the materials which can be conveniently obtained to achieve development.

[0003] Taking the photovoltaic cell industry as an example, the currently available photovoltaic cells adopt low-cost metals to replace some or all silver paste. When producing the photovoltaic cells, the cost of the silver paste is more than 25% of the total cost of the production process. It is obvious that using the low-cost metals to replace some or all silver paste is very important for reducing the cost of the production of the photovoltaic cells.

[0004] More specifically, using copper, to replace the expensive silver past is a great idea. However, the copper ions would easily diffuse into the crystalline silicon in high temperature, so the service life of the crystalline silicon would decrease accordingly and the photoelectric conversion efficiency of the crystalline silicon photovoltaic cells would also decrease. Accordingly. Thus, it is necessary to deposit the copper on the surfaces of the crystalline silicon photovoltaic cells in low temperature in order to produce the reliable conductive electrodes of the crystalline silicon photovoltaic cells.

[0005] There are two approaches to produce the electrodes of the crystalline silicon photovoltaic cells by depositing the copper on the surfaces of the crystalline silicon photovoltaic cells in low temperature during the production process. One approach is low-temperature physical deposition method, and the other approaches chemical deposition method. The low-temperature physical deposition method is based on sputtering and the shortcoming thereof is that this method cannot selectively deposit the metals without masks; besides, this method also needs expensive lithography equipment, which significantly increase the production cost. Thus, this method cannot achieve the objective of cost reduction.

[0006] The chemical deposition method is based on electroplating process. Compared with the physical deposition method, the electroplating process is simpler and can selectively deposit the metals. Therefore, the production cost of the electroplating process can be very low, so the cost of the production of the crystalline silicon photovoltaic cells can be considerably reduced. Accordingly, using the electroplating process to deposit the metals on the crystalline silicon photovoltaic cells is a popular development field for now.

[0007] Regarding the designs of the currently available single-sided or double-sided horizontal type electroplating equipment for printed circuit boards, photovoltaic cells and semiconductor chips, the cathodes of these equipment usually adopt hard conductive metal materials because there is no proper elastic conductive material. However, the objects to be plated are usually fragile, so tend to be crushed during the production process, which is not good for mass production. By the way, part of the cathodes of these equipment can also adopt elastic conductive fiber materials which are made by doping metal powders or graphite powders into non-conductive fibers, so the shortcoming of this method is that the electric conductivity of the elastic conductive fiber materials is insufficient. For the reason, the elastic conductive fiber materials cannot bear the large current passing through during the electroplating process and the electric conductivity thereof would also decrease in a short time because the conductive powders drop off or the materials corroded by the electroplating solution. The present invention provides a conductive cathode to perform the single-sided or double-sided horizontal electroplating process so as to solve the aforementioned problem.

[0008] As set forth above, the currently available electroplating equipment for horizontal electroplating are usually designed to use a hard metal rolling rod to serve as the cathode. Thus, during the rolling step of the electroplating process, the objects to be plated (e.g. photovoltaic cells and semiconductor chips) tend to be crushed. Another shortcoming is that the cathode rolling rod made of hard materials cannot properly and stably contact the object to be plated. In fact, the cathode rolling rod keeps jumping up and down over the surface of the object to be plated, so many electric arcs may be generated during the electroplating process. The electric arcs would damage the object to be plated or break through the object to be plated, which would influence the quality of the products.

SUMMARY OF THE INVENTION

[0009] So as to overcome the shortcomings of prior art, the present invention provides an electrode structure of a single-sided or double-sided horizontal type electroplating equipment applicable for semiconductor chips, printed circuit boards and photovoltaic cells, which can effectively avoid that the object to be plated is crushed during the electroplating process, increase the service life of the cathode, and make sure that the electrical contact between the cathode and the object to be plated is

proper and stable. Besides, large current is allowed to pass through the electrode structure during the electroplating process, which can prevent from the generation of the electric arcs in order to increase the operational speed of the equipment and produce high-quality products in mass production.

[0010] To achieve the foregoing objective, the present invention provides a new electrode structure for a single-sided or double-sided horizontal or vertical type electroplating equipment, which includes a conductive shaft connected to an electric source. A soft and flexible conductive layer tubular in shape is sheathed on the conductive shaft and the two ends of the conductive layer are provided with conductive terminals directly contacting the conductive shaft respectively. The outer surface of the conductive layer forms a cathode electrically contacting an object to be plated and a cavity is formed between the inner surface of the conductive layer and the conductive shaft. The buffer cushion layer is disposed inside the cavity, and the outer surface and the inner surface of the buffer layer press against the conductive shaft and the conductive layer.

[0011] The advantages of the present invention are as follows:

Via the conductive terminals contacting the conductive shaft, the electrical connection between the conductive layer and the electric source is realized, such that the cathode, needed by the electroplating process, can be formed on the outer surface, for pressing the object to be plated by rolling, of the conductive layer. The buffer cushion layer disposed inside the cavity can provide flexible support for the cathode contacting the object to be plated in order to maintain the proper flexible and soft pressing contact between the cathode and the object to be plated, which can further prevent from fire electrical arcing or sparks generated and finally increasing the yield rate of the manufacturing by the electroplating process.

[0012] In a preferred embodiment of the present invention, the buffer cushion layer is made of an elastic material, and the elastic material is plastics or rubber.

[0013] In a preferred embodiment of the present invention, the diameter of the conductive shaft is 1mm-100mm and the length of the conductive shaft is 1mm-5000mm.

[0014] In a preferred embodiment of the present invention, the soft and flexible conductive layer is made of conductive fibers and the diameter of each of the conductive fibers is 0.005~100um.

[0015] In a preferred embodiment of the present invention, the conductive fibers are made of one or more materials selecting from the group consisting of stainless steel, nickel, titanium, tungsten, graphite and metal alloy.

[0016] In a preferred embodiment of the present invention, the cathode is a full contact without clip or chucking point structure.

[0017] The present invention is applicable to single-sided or double-sided horizontal or vertical type electroplating equipment for semiconductor chips, printed circuit boards and photovoltaic cells. The electroplating equipment include the above electrode.

[0018] Taking the photovoltaic cell industry and semiconductor chip manufacturing industry as examples, the advantages of the single-sided or double-sided horizontal type electroplating equipment in accordance with the present invention are that when the single-sided or double-sided horizontal type electroplating equipment for manufacturing semiconductor chips and photovoltaic cells adopt the cathode, the object to be plated will not be damaged by the cathode, and the proper flexible and soft pressing contact between the cathode and the object to be plated can be maintained in order to improve the uniformity of the electroplating effect and increase the yield rate of the products manufactured by the electroplating process.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] For a better understanding of the aforementioned embodiments of the invention as well as additional embodiments thereof, reference should be made to the Description of Embodiments below, in conjunction with the following drawings in which like reference numerals refer to corresponding parts throughout the figures.

Fig. 1 is the schematic view of the 3D structure of the improved electrode structure in accordance with one embodiment of the present invention.

Fig. 2 is the front view of the improved electrode structure in accordance with one embodiment of the present invention.

Fig. 3 is the sectional view of the improved electrode structure in accordance with one embodiment of the present invention.

Fig. 4 is the schematic view of the 3D structure of the single-sided or double-sided horizontal type electroplating equipment in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0020] The following description is about embodiments of the present invention; however it is not intended to limit the scope of the present invention.

[0021] Please refer to Fig. 1 ~ Fig. 3, which show an electrode structure of a single-side or double-sided horizontal type electroplating equipment; the electrode structure includes a conductive shaft 1 connected to an electric source. A tubular conductive layer 2 is sheathed on the conductive shaft 1. An application example of the conductive shaft 1 and the conductive layer 2 is as shown in Fig.3; the conductive shaft 1 with the conductive layer 2 are installed on a currently available single-sided or double-sided horizontal type electroplating equipment 4. The electroplating equipment 4 is loaded with an object to be plated 5 and move the object to be plated to pass through the working area. The upper side and the lower

side of the working area are provided with the electroplating solution containers 6 respectively. The electroplating solution is dripped or poured on one surface or two surfaces of the object to be plated 5. The surface of the object to be plated 5, close to the electroplating solution container 6, serves as an anode and the surface, contacting the object to be plated 5 and on the both side of the electroplating solution container 6, of conductive layer 2 of the present invention serves as a cathode, such that the object to be plated 5 can electrically connect the anode to the cathode in order to perform the single-sided or double-sided electroplating process.

[0022] The present invention is characterized in that the conductive layer 2 is sheathed on the conductive shaft 2, as shown in Fig. 1~Fig. 3. The two ends of the conductive layer 2 are provided with conductive terminals 21 directly contacting the conductive shaft 1 respectively. The outer surface of the conductive layer 2 forms the cathode electrically contacting an objected to be plated 5 and a cavity 22 is formed between the inner surface of the conductive layer 2 and the conductive shaft 1. The buffer layer 3 is disposed inside the cavity 22, and the outer surface and the inner surface of the buffer layer 3 press against the conductive shaft 1 and the conductive layer 2.

[0023] Via the conductive terminals 21 contacting the conductive shaft 1, the electrical connection between the conductive layer 2 and the electric source is realized, such that the cathode, needed by the electroplating process, can be formed on the outer surface, for pressing the object to be plated 5 by rolling, of the conductive layer 2. The buffer layer 3 disposed inside the cavity 22 can provide flexible support for the cathode contacting the object to be plated 5 in order to maintain the proper flexible and soft pressing contact between the cathode and the object to be plated 5, which can prevent from damaging the fragile objects and can further prevent from fire electrical sparks generated because the object to be plated 5 is damaged by the currently available cathode for the purpose of increasing the yield rate of the products manufactured by the electroplating process.

[0024] In the embodiment, the buffer layer 3 can be made of an elastic material material. The elastic material may be any one of PP, PE, PVC, PU and PO.

[0025] In the embodiment, the diameter of the conductive shaft 1 is 1mm-100mm and the length of the conductive shaft 1 is 1mm-5000mm.

[0026] In the embodiment, the conductive layer 2 may adopt conductive fibers and the conductive fibers are made of one or more materials selecting from the group consisting of stainless steel, nickel, titanium, tungsten, graphite and copper alloy.

[0027] Via the conductive layer 2 and the buffer layer 2, a full contact without clips or chucking point structure is formed between the cathode and the object to be plated 5 in the embodiment. The key point of implementing a common electroplating process is that the object to be plated 5 should contact the cations and the negative electrode (cathode) at the same time, and the metal grid lines needed by the object to be plated 5 (e.g. a semiconductor chip, a printed circuit board or a photovoltaic cell) can obtain electrons from the surface, contacting the cathode, of the object to be plated 5. Then, the metal cations in the electroplating solution can be plated on the object surface. However, all of the currently available electroplating equipment implement the electroplating process by using clips as a cathode to contact object surface; this design tends to make the semiconductor chip or the fragile photovoltaic cells be damaged due to high clamping forces on plating objects. This design also has the shortcomings that the plated patterns on object surface having low uniformity, and it needs to have the clamping pads design on the plating patterns. However, as the electrode structure of the embodiment includes the conductive layer 2 (the conductive fibers) and the buffer layer 3, the object to be plated 5 can pass through the cathode without clips during the electroplating process, and a firmly soft and good contact between the conductive layer 2 and the object to be plated 5, a semiconductor chip or a photovoltaic cell, can be formed, which not only can maintain great electroplating uniformity, but also can avoid that the fragile objects are damaged.

[0028] The single-sided or double-sided horizontal type electroplating equipment 4 of the present invention for manufacturing photovoltaic cells includes the above electrode. The electroplating equipment 4 adopts the aforementioned cathode, which not only can make sure that the object to be plated 5 processed by the electroplating equipment 5 will not be damaged because being clamped by the cathode, but also can make sure that the object 5 to be plated can have great and stable conductive flexible contact in order to increase the yield rate of the products manufactured by the electroplating process.

[0029] The above disclosure is related to the detailed technical contents and inventive features thereof. Those skilled in the art may proceed with a variety of modifications and replacements based on the disclosures and suggestions of the invention as described without departing from the characteristics thereof. Nevertheless, although such modifications and replacements are not fully disclosed in the above descriptions, they have substantially been covered in the following claims as appended.

Claims

1. An electrode structure for a single-sided or double-sided horizontal type electroplating equipment, comprising a conductive shaft connected to an electric source, **characterized in that** wherein a soft and flexible conductive layer tubular in shape is sheathed on the conductive shaft and two ends of the conductive layer are provided with conductive terminals directly contacting the conductive shaft respectively, wherein an outer surface of the conductive layer forms a cathode electrically contacting an object to

be plated and a cavity is formed between an inner surface of the conductive layer and the conductive shaft, wherein a buffer cushion layer is disposed inside the cavity, and an outer surface and an inner surface of the buffer layer press against the conductive shaft and the conductive layer.

2. The electrode structure for a single-sided or double-sided horizontal type electroplating equipment of claim 1, wherein the buffer cushion layer is made of an elastic material, and the elastic material can be plastics, sponges or rubbers.

3. The electrode structure for a single-sided or double-sided horizontal or vertical type electroplating equipment of claim 1, wherein a diameter of the conductive shaft is 1mm-100mm and a length of the conductive shaft is 1mm-5000mm.

4. The electrode structure for a single-sided or double-sided horizontal type electroplating equipment of any of claims 1 to 4, wherein the conductive layer is made of conductive fibers and a diameter of each of the conductive fibers is 0.005um-100um, wherein a length of each of external fibers connected to the conductive fibers is 0mm-1000mm.

5. The electrode structure for a single-sided or double-sided horizontal type electroplating equipment of claim 5, wherein the conductive fibers are made of one or more materials selecting from a group consisting of stainless steel, nickel, titanium, tungsten, graphite and metal alloy.

6. The electrode structure for a single-sided or double-sided horizontal type electroplating equipment of claim 5, wherein the cathode is a full contact without clips design or chucking point structure.

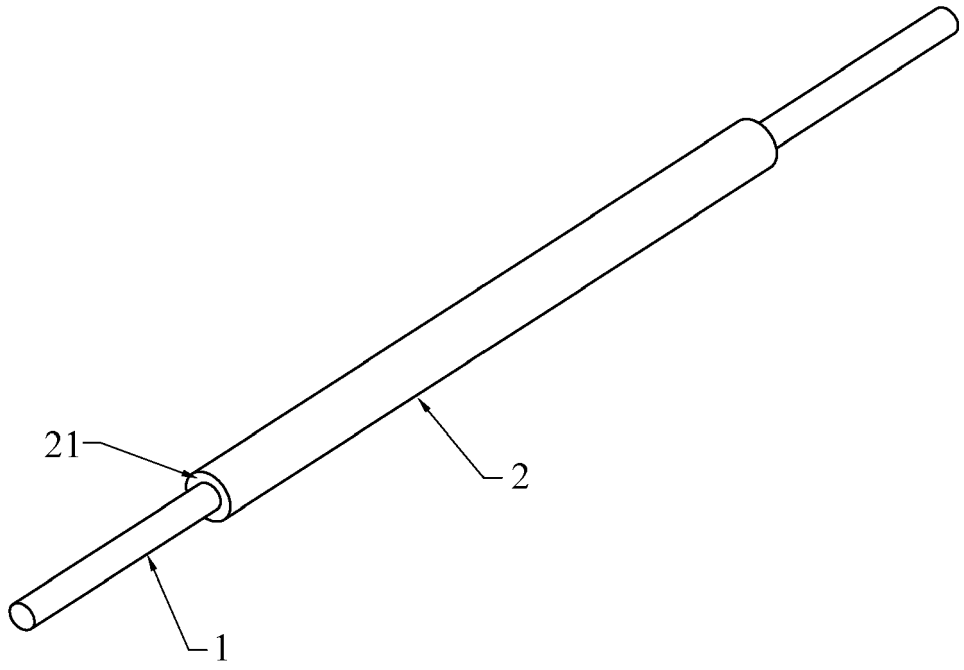

FIG. 1

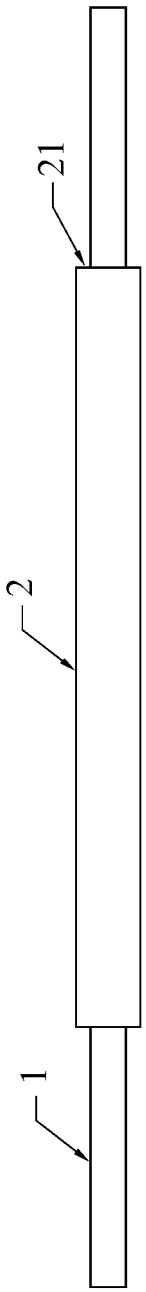

FIG. 2

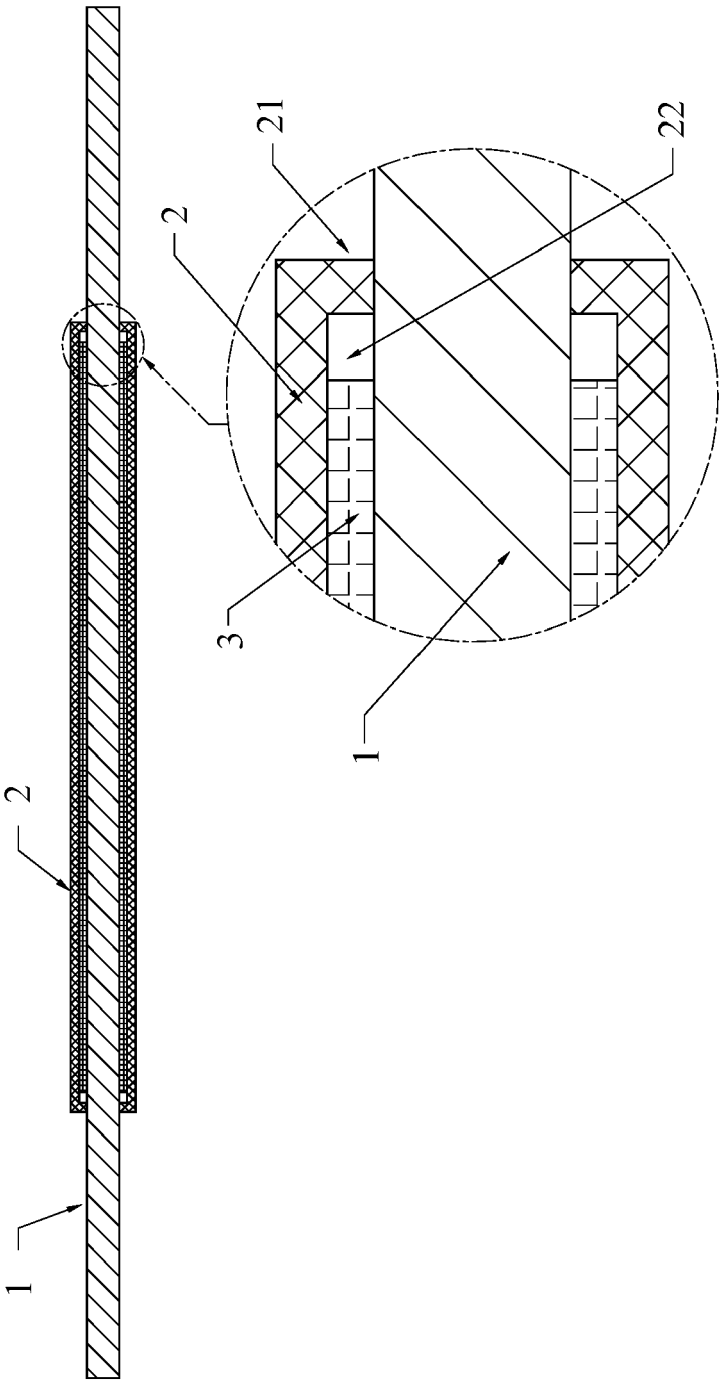

FIG. 3

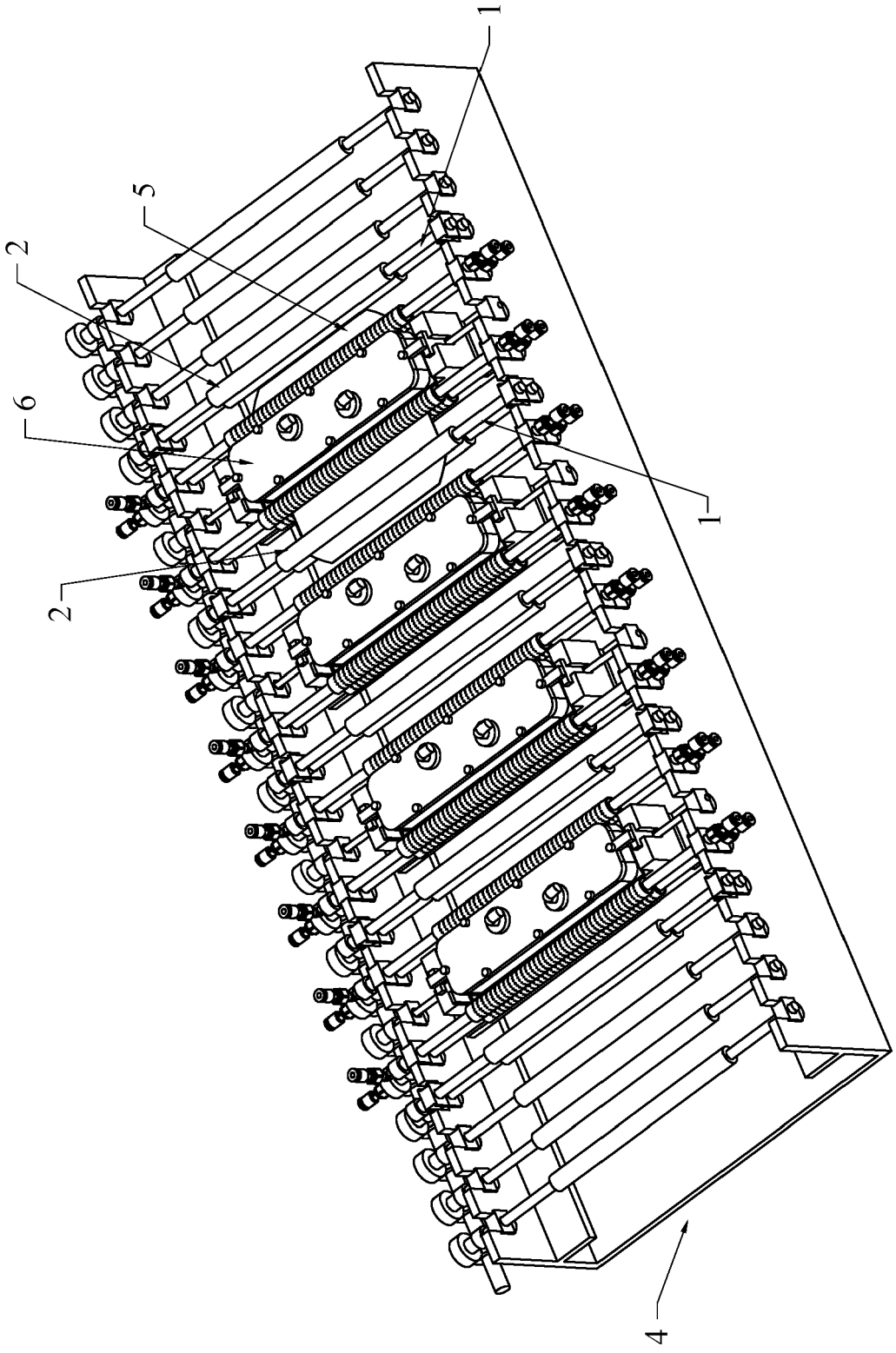

FIG. 4

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 20 18 1936

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	WO 2004/101865 A2 (SCHMID GMBH & CO GEB [DE]; SCHMID CHRISTIAN [DE]) 25 November 2004 (2004-11-25) * page 9, line 8 - page 11, line 25 * * figures 1,2 *	1-6	INV. C25D17/00
A	JP S61 207598 A (NOMURA SEIMITSU DENSHI KK) 13 September 1986 (1986-09-13) * the whole document *	1-6	
A	US 2003/051999 A1 (HUBEL EGON [DE]) 20 March 2003 (2003-03-20) * paragraphs [0052] - [0054] * * figures 1a-1c *	1-6	
A	US 2 513 515 A (POWERS WILLIAM A) 4 July 1950 (1950-07-04) * column 1, line 47 - column 2, line 25 *	1-6	
A	EP 2 061 073 A2 (RENA SONDERMASCHINEN GMBH [DE]) 20 May 2009 (2009-05-20) * paragraph [0046] - paragraph [0051] * * figure 1 *	1-6	TECHNICAL FIELDS SEARCHED (IPC) C25D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	19 November 2020	Le Hervet, Morgan

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 20 18 1936

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

19-11-2020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2004101865 A2	25-11-2004	AT 411415 T	15-10-2008
		CN 1791703 A	21-06-2006
		DE 10323660 A1	02-12-2004
		EP 1623057 A2	08-02-2006
		JP 2006529004 A	28-12-2006
		KR 20060022240 A	09-03-2006
		TW 200425815 A	16-11-2004
		WO 2004101865 A2	25-11-2004
JP S61207598 A	13-09-1986	NONE	
US 2003051999 A1	20-03-2003	AT 278823 T	15-10-2004
		AU 7384901 A	07-11-2001
		BR 0110114 A	11-02-2003
		CA 2402805 A1	01-11-2001
		CN 1429284 A	09-07-2003
		DE 10019713 A1	31-10-2001
		EP 1309740 A2	14-05-2003
		HK 1056753 A1	27-02-2004
		JP 4681789 B2	11-05-2011
		JP 2003531301 A	21-10-2003
		KR 20030011297 A	07-02-2003
		MX PA02010309 A	23-05-2003
		TW 548348 B	21-08-2003
		US 2003051999 A1	20-03-2003
		WO 0181657 A2	01-11-2001
US 2513515 A	04-07-1950	NONE	
EP 2061073 A2	20-05-2009	DE 102007054092 A1	28-05-2009
		EP 2061073 A2	20-05-2009

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82