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

(11) **EP 3 156 523 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
19.04.2017 Bulletin 2017/16

(21) Application number: **14894211.3**

(22) Date of filing: **29.11.2014**

(51) Int Cl.:
C25D 17/00 *(2006.01)* ***C25D 7/06*** *(2006.01)*
C25D 17/06 *(2006.01)*

(86) International application number:
PCT/CN2014/092599

(87) International publication number:
WO 2015/188597 (17.12.2015 Gazette 2015/50)

(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

(30) Priority: **11.06.2014 CN 201410256977**

(71) Applicant: **Shanghai Meishan Iron & steel Co., Ltd.**
Nanjing, Jiangsu 210039 (CN)

(72) Inventors:
- **ZHANG, Rongpin**
  Nanjing
  Jiangsu 210039 (CN)
- **LU, Yongliang**
  Nanjing
  Jiangsu 210039 (CN)
- **WANG, Haijun**
  Nanjing
  Jiangsu 210039 (CN)

(74) Representative: **Prol European Patent Attorneys**
Postfach 2123
90711 Fürth (DE)

(54) **CONTINUOUS ELECTROPLATING TEST DEVICE SIMULATING DIFFERENT LINEAR SPEEDS OF BAND STEEL**

(57) The present invention relates to a continuous electroplating test apparatus capable of simulating different linear velocities of strip steel, characterized in that the test apparatus comprises a supporting underframe, a workbench is arranged on the supporting underframe, a working bath is fixedly arranged on the workbench, the test apparatus also comprises a working electrode system, a transmission shaft, an auxiliary electrode and a specimen working electrode, the transmission shaft is connected with the working electrode system, the auxiliary electrode and the working electrode system are both connected with a rectifier to constitute a closed loop, the specimen working electrode is arranged on the working electrode system, and the high-speed production process of the strip steel is simulated by adjusting the rotation of a motor. The test apparatus can simulate the whole process of continuous production of the strip steel, comprising alkali washing, pickling, electroplating, passivating and other technological processes. The whole process can be simulated, and a certain technological process can also be independently simulated. The simulation tests do not interfere with one another so as to further ensure the accuracy of the tests.

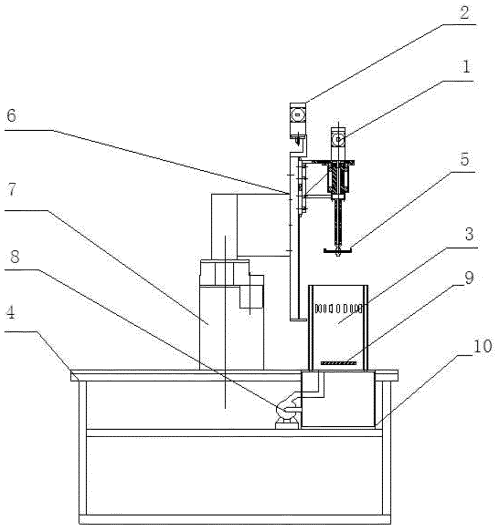

FIG. 1

EP 3 156 523 A1

Description

BACKGROUND

Technical Field

[0001] The present invention relates to an electroplating test apparatus, and particularly relates to a continuous electroplating test apparatus capable of simulating different linear velocities of strip steel, belonging to the technical field of electroplating.

Related Art

[0002] The electroplating process is a complex electrochemical process, and the quality of electroplating products is further related to the plating piece surface conditions, the bath flow conditions, the relative speeds of a bath and a plating piece and other factors in addition to the formula of the bath. Laboratory simulation of electroplating mainly includes two ways of static simulation and dynamic simulation, and the dynamic electroplating way is often used to conduct a test in order to truly reflect the process operating state of electroplating. In an ordinary dynamic test, only one fixed speed can be selected and used to conduct a simulation test, and the efficiency is relatively low. The continuous electroplating tests of different linear velocities can be conducted through a rotating disk electrode, and a potential variation curve can be monitored by an electrochemical workstation; however, a test piece obtained by the method is smaller, and the morphology analysis on different parts of the test piece cannot be conducted by a scanning microscope to investigate the plating morphology, grains and other information. Therefore, there is a need for a continuous electroplating test apparatus capable of simulating different linear velocities of strip steel.

SUMMARY

[0003] The present invention provides a test apparatus which has skillful structural design, can realize the high-speed continuous electroplating of strip steel, also can obtain the test results of multiple linear velocities through a single test, and is used to evaluate bath limit electroplating performance parameters in order to solve the technical problems existing in the prior art.

[0004] In order to achieve the above-mentioned object, the present invention adopts the following technical solution: a continuous electroplating test apparatus capable of simulating different linear velocities of strip steel is characterized in that the test apparatus comprises a supporting underframe, a workbench is arranged on the supporting underframe, a working bath is fixedly arranged on the workbench, the test apparatus also comprises a working electrode system, a transmission shaft, an auxiliary electrode and a specimen working electrode, the transmission shaft is connected with the working electrode system, the auxiliary electrode and the working electrode system are both connected with a rectifier to constitute a closed loop, the specimen working electrode is arranged on the working electrode system, the function exchange of an anode and a cathode is realized by changing the positive and negative electrodes of the rectifier, so as to realize the simulation of the electroplating and cleaning processes, and the high-speed production process of the strip steel is simulated by adjusting the rotation of a motor.

[0005] As an improvement on the present invention, the motor comprises a rotating motor and a vertical lifting motor, the vertical lifting motor is used to realize a vertical movement, and the rotating motor driving a working motor through the transmission shaft to realize the high-speed rotation of the working electrode system.

[0006] As an improvement on the present invention, the working electrode system comprises an upper nut, a lower nut, an upper gasket, a lower gasket, polytetrafluoroethylene and a circular sealing ring, the upper and lower sides of the polytetrafluoroethylene are respectively provided with the upper gasket and the lower gasket, and are respectively fixed by the upper nut and the lower nut, and the circular sealing ring is arranged around the polytetrafluoroethylene. The upper nut and the lower nut are used to fix the polytetrafluoroethylene and the working electrode, the polytetrafluoroethylene with a threaded center shaft can be rotated and fastened onto the transmission shaft, the specimen working electrode is punched in the center and then is fitted to the lower surface of the polytetrafluoroethylene, and the working electrode is fixed by the lower nut. Meanwhile, the circular sealing ring is sleeved on the upper surface of the polytetrafluoroethylene and the edge part of the lower surface of the specimen working electrode in a clamping way, so as to prevent the bath from flowing to a part between the polytetrafluoroethylene and the specimen working electrode, causing the movement of the working electrode and affecting the electroplating effect.

[0007] As an improvement on the present invention, the diameter of the auxiliary electrode is greater than that of the working electrode system. The phenomenon of uneven distribution of power lines in the electroplating process is avoided.

[0008] As an improvement on the present invention, the workbench is arranged to be a rotating platform. The platform can freely rotate at an angle of 360 degrees so as to facilitate the conduction of the test.

[0009] As an improvement on the present invention, the test apparatus also comprises a moving screw, and the vertical lifting motor drives the moving screw to conduct up-and-down movement.

[0010] As an improvement on the present invention, the quantity of the working baths is at least one. Generally, seven working baths are arranged and are respectively configured to conduct related work such as pickling, alkali washing, fluxing, soft melting, passivating, electroplating and cleaning.

[0011] As an improvement on the present invention, the working electrode system comprises an internal threaded bottom cap, a hexagon socket bolt, an annular seal ring, a stainless steel bottom disc, a spring and an external threaded housing, the transmission shaft and the stainless steel bottom disc are welded together, the spring is fixedly arranged on the transmission shaft through the hexagon socket bolt, the annular sealing ring is embedded in the internal threaded bottom cap, and the internal threaded bottom cap is connected with the external threaded housing through the annular sealing ring, so that a solution can be prevented from entering the working electrode system and affecting the electroplating effect; in the technical solution, when the working electrode system is connected with the transmission shaft, the contact area can be increased through connection of the spring, so that the good electrical conduction effect can be maintained.

[0012] As an improvement on the present invention, the working electrode system is fixedly arranged on the transmission shaft through fastening threads.

[0013] Compared with the prior art, the technical advantages are as follows: 1) the test apparatus can simulate the whole process of continuous production of the strip steel, comprising alkali washing, pickling, electroplating, passivating and other technological processes; the whole process can be simulated, and a certain technological process can also be independently simulated; the simulation tests do not interfere with one another, so as to further ensure the accuracy of the tests;2) in the technical solution, the independent process of a vertical movement and a rotary movement is realized by a combination way of the rotating motor and the vertical lifting motor; the strip steel obtains certain angular velocities by adjusting the rotational speed of the rotating motor, and the angular velocities are converted into different linear velocities; 3) in the technical solution of the present invention, under a certain angular velocity, the linear velocities of a round steel plate gradually increase from the center to the periphery; through the conversion relationship between the angular velocity and the linear velocity, steel plate specimens of different linear velocities can be obtained by conducting a single test, and the electroplating states of the bath at different linear velocities can be better evaluated, so as to obtain the best working window of the bath; 4) the test apparatus has the characteristics of simple and convenient operation, high efficiency, safe operation, high experimental accuracy and the like; 5) in the technical solution, various working electrode structures are provided, so that the solution is prevented from entering the working electrode, and thus the electroplating effect is further ensured.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1 is a schematic diagram of an overall structure of a test apparatus according to the present invention.

Fig. 2 is a diagram of a closed loop according to the present invention.

Fig. 3 is an enlarged view of a working electrode system according to the present invention.

Fig. 4 is a structural schematic diagram of another working electrode according to the present invention.

Fig. 5 is a vertical view of Fig. 4.

[0015] In the drawings: 1. rotating motor, 2. vertical lifting motor, 3. working bath, 4. supporting underframe, 5. working electrode system, 6. moving screw, 7. rotating platform, 8. circulating pump, 9. auxiliary electrode, 10. reservoir, 11. transmission shaft, 12. upper nut, 13. lower nut. 14. upper gasket, 15. lower gasket, 16. polytetrafluoroethylene, 17. circular sealing ring, 18. specimen working electrode, 19. rectifier, 20. internal threaded bottom cap, 21. hexagon socket bolt, 22. annular sealing ring, 23. stainless steel bottom disc, 24. spring, 25. fastening threads, and 26. external threaded housing.

DETAILED DESCRIPTION

[0016] In order to deeply understand and recognize the present invention, the present invention is further described and introduced in conjunction with the accompanying drawings and specific embodiments hereinafter.

Example 1: Refer to fig. 1, a continuous electroplating test apparatus capable of simulating different linear velocities of strip steel. The test apparatus comprises a supporting underframe 4, a workbench is arranged on the supporting underframe 4, a working bath 3 is fixedly arranged on the workbench, and the test apparatus also comprises a working electrode system 5, a transmission shaft 11, an auxiliary electrode 9 and a specimen working electrode 18, the transmission shaft 11 is connected with the working electrode system 5, the auxiliary electrode 9 and the working electrode system 5 are both connected with a rectifier to constitute a closed loop, the specimen working electrode 18 is arranged on the working electrode system 5, the function exchange of an anode and a cathode is realized by changing the positive and negative electrodes of the rectifier, so as to realize the simulation of the electroplating and cleaning processes, and the high-speed production process of the strip steel is simulated by adjusting the rotation of a motor. The test apparatus can simulate the whole process of continuous production of the strip steel, comprising alkali washing, pickling, electroplating, passivating and other technological processes. The whole process can be simulated, and a certain technological process can also be independently simulated. The simulation tests do not interfere with one another, so as to further ensure the accu-

racy of the tests.

Example 2: Refer to Fig. 1, as an improvement on the present invention, the motor comprises a rotating motor 1 and a vertical lifting motor 2, the vertical lifting motor 2 is used for realizing a vertical movement, and the rotating motor 1 drives a working motor through the transmission shaft 11 to realize the high-speed rotation of the working electrode system. The remaining structure and advantages are identical to Example 1.

Example 3: Refer to Fig. 2, as an improvement on the present invention, the diameter of the auxiliary electrode 9 is greater than that of the working electrode system 5. The phenomenon of uneven distribution of power lines in the electroplating process is avoided. The remaining structure and advantages are identical to Example 1.

Example 4: Refer to Fig. 1, as an improvement on the present invention, the workbench is arranged to be a rotating platform 7. The platform can freely rotate at an angle of 360 degrees so as to facilitate the conduction of the test. The remaining structure and advantages are identical to Example 1.

Example 5: Refer to Fig. 1, as an improvement on the present invention, the test apparatus also comprises a moving screw 6, and the vertical lifting motor 2 drives the moving screw 6 to conduct up-and-down movement. The remaining structure and advantages are identical to Example 1.

Example 6: Refer to Fig. 1, as an improvement on the present invention, the quantity of the working bath 3 is at least one. Generally, seven working baths are arranged and are respectively configured to conduct related work such as pickling, alkali washing, fluxing, soft melting, passivating, electroplating and cleaning. The remaining structure and advantages are identical to Example 1.

Example 7: Refer to Fig. 2 and Fig. 3, as an improvement on the present invention, the working electrode system 5 comprises an upper nut 12, a lower nut 13, an upper gasket 14, a lower gasket 15, polytetrafluoroethylene 16 and a circular sealing ring 17, the upper and lower sides of the polytetrafluoroethylene 16 are respectively provided with the upper gasket 14 and the lower gasket 15, and are respectively fixed by the upper nut 12 and the lower nut 13, and the circular sealing ring 17 is arranged around the polytetrafluoroethylene. The upper nut 12 and the lower nut 13 are configured to fix the polytetrafluoroethylene 16 and the specimen working electrode 18, the polytetrafluoroethylene with a threaded center shaft can be rotated and fastened onto the transmission shaft 11, the specimen working electrode 18 is punched in the center and then is fitted to the lower surface of the polytetrafluoroethylene 16, and the specimen working electrode 18 is fixed by the lower nut. Meanwhile, the circular sealing ring 17 is sleeved on the upper surface of the polytetrafluoroethylene and the edge part of the lower surface of the specimen working electrode in a clamping way, so as to prevent bath from flowing to a part between the polytetrafluoroethylene and the specimen working electrode, causing the movement of the specimen working electrode, and affecting the electroplating effect. The remaining structure and advantages are identical to Example 1.

Example 8: Refer to Fig. 4 and Fig. 5, as an improvement on the present invention, the working electrode system 5 comprises an internal threaded bottom cap 20, a hexagon socket bolt 21, an annular seal ring 22, a stainless steel bottom disc 23, a spring 24 and an external threaded housing 26, the transmission shaft 11 and the stainless steel bottom disc 23 are welded together, the spring 24 is fixedly arranged on the transmission shaft 11 through the hexagon socket bolt 21, the annular sealing ring 22 is embedded in the internal threaded bottom cap 20, and the internal threaded bottom cap 20 is connected with the external threaded housing 26 through the annular sealing ring 22, so that a solution is prevented from entering the working electrode system and affecting the electroplating effect; in the technical solution, when the working electrode system 5 is connected with the transmission shaft 11, the contact area can be increased through connection of the spring 24, so that the good electrical conduction effect can be maintained. The remaining structure and advantages are identical to Example 1.

[0017] The test process is briefly described as follows: first, a wafer with a diameter of 10 cm is cut to be ready for use, and the working electrode system is fixedly arranged on the transmission shaft 11 through the fastening threads 25; then, the circular working electrode is stuck to the bottom of the stainless steel bottom disc 15, the internal threaded bottom cap 20 with the embedded annular sealing ring 22 is screwed onto the external threaded housing 26, and the test can be started by turning on a power supply; finally, after the test is finished, the internal threaded bottom cap is unscrewed, so that the circular working electrode can be removed.

[0018] In the present invention, a novel embodiment can also be formed by a combination of at least one of the technical characteristics of Examples 2, 3, 4, 5, 6 and 7 and Example 1.

[0019] In the present invention, a novel embodiment can also be formed by a combination of at least one of the technical characteristics of Examples 2, 3, 4, 5,6 and 8 and Example 1.

[0020] It is to be illustrated that the above-mentioned examples are not used to limit the scope of protection of the present invention. The equivalent transformations or replacements made on the basis of the above-mentioned technical solutions all fall within the scope of the claims of the present invention.

Claims

1. A continuous electroplating test apparatus capable of simulating different linear velocities of strip steel, **characterized in that** the test apparatus comprises a supporting underframe, a workbench is arranged on the supporting underframe, a working bath is fixedly arranged on the workbench, the test apparatus also comprises a working electrode system, a transmission shaft, an auxiliary electrode and a specimen working electrode, the transmission shaft is connected with the working electrode system, the auxiliary electrode and the working electrode system are both connected with a rectifier to constitute a closed loop, the specimen working electrode is arranged on the working electrode system, and the high-speed production process of strip steel is simulated by adjusting the rotation of a motor.

2. The continuous electroplating test apparatus capable of simulating different linear velocities of strip steel according to claim 1, **characterized in that** the motor comprises a rotating motor and a vertical lifting motor, and the vertical lifting motor is connected with a rotating platform to realize a vertical movement; the rotating motor is connected with a moving screw of the vertical lifting motor, and the high-speed rotation of the working electrode system is achieved through the transmission shaft.

3. The continuous electroplating test apparatus capable of simulating different linear velocities of strip steel according to claim 2, **characterized in that** the diameter of the auxiliary electrode is greater than that of the working electrode system.

4. The continuous electroplating test apparatus capable of simulating different linear velocities of strip steel according to claim 3, **characterized in that** the workbench is arranged to be a rotating platform.

5. The continuous electroplating test apparatus capable of simulating different linear velocities of strip steel according to claim 3 or 4, **characterized in that** the test apparatus also comprises a moving screw, the moving screw occludes through threads, the rotating motor is connected with the moving screw, and the vertical lifting motor drives the rotating motor and the working electrode system to move up and down through the moving screw.

6. The continuous electroplating test apparatus capable of simulating different linear velocities of strip steel according to claim 5, **characterized in that** the quantity of the working bath is at least one.

7. The continuous electroplating test apparatus capable of simulating different linear velocities of strip steel according to claim 6, **characterized in that** the working electrode system comprises an upper nut, a lower nut, an upper gasket, a lower gasket, polytetrafluoroethylene and a circular sealing ring, the upper and lower sides of the polytetrafluoroethylene are respectively provided with the upper gasket and the lower gasket, and are respectively fixed by the upper nut and the lower nut, and the circular sealing ring is arranged around the polytetrafluoroethylene.

8. The continuous electroplating test apparatus capable of simulating different linear velocities of strip steel according to claim 6, **characterized in that** the working electrode system comprises an internal threaded bottom cap, a hexagon socket bolt, an annular seal ring, a stainless steel bottom disc, a spring and an external threaded housing, the transmission shaft and the stainless steel bottom disc are welded together, the spring is fixedly arranged on the transmission shaft through the hexagon socket bolt, the annular sealing ring is embedded in the internal threaded bottom cap, and the internal threaded bottom cap is connected with the external threaded housing through the annular sealing ring.

9. The continuous electroplating test apparatus capable of simulating different linear velocities of strip steel according to claim 7 or 8, **characterized in that** the working electrode system is fixedly arranged on the transmission shaft through fastening threads.

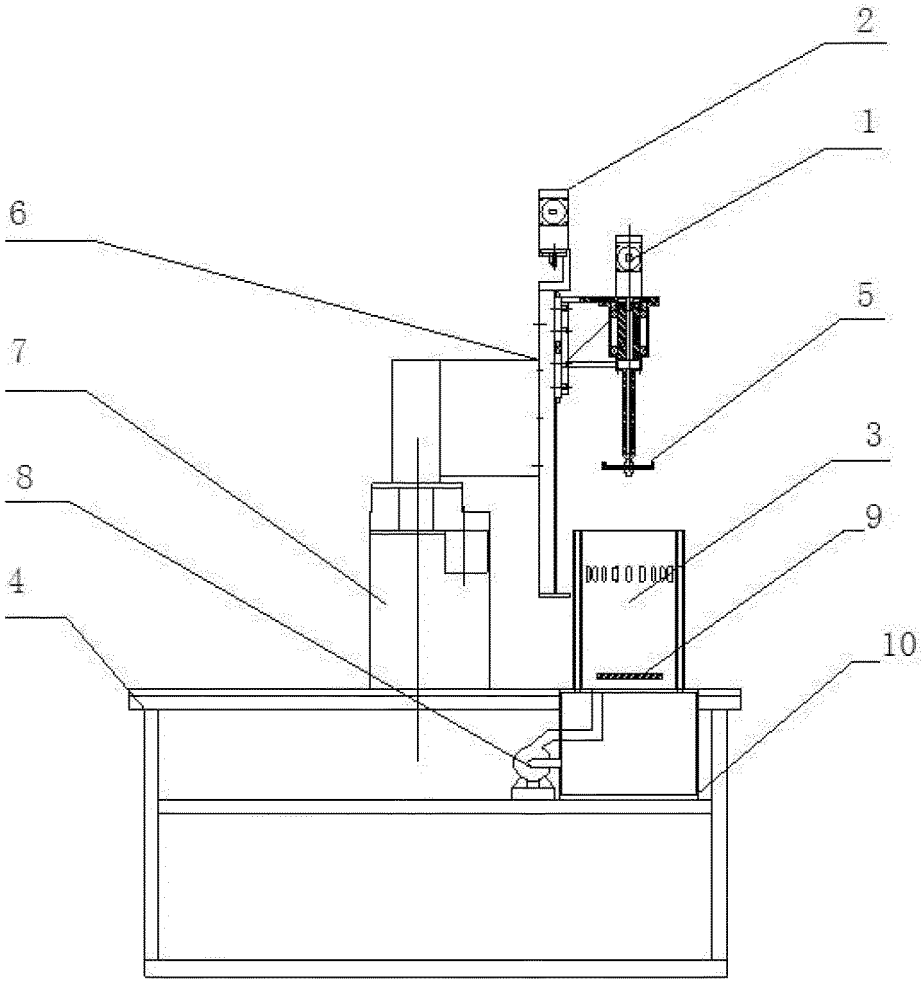

FIG. 1

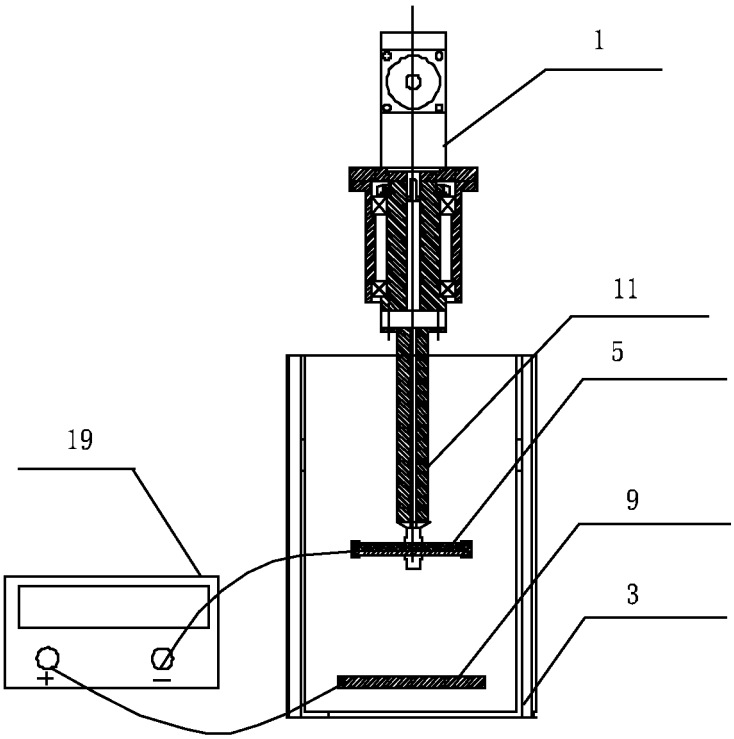

FIG. 2

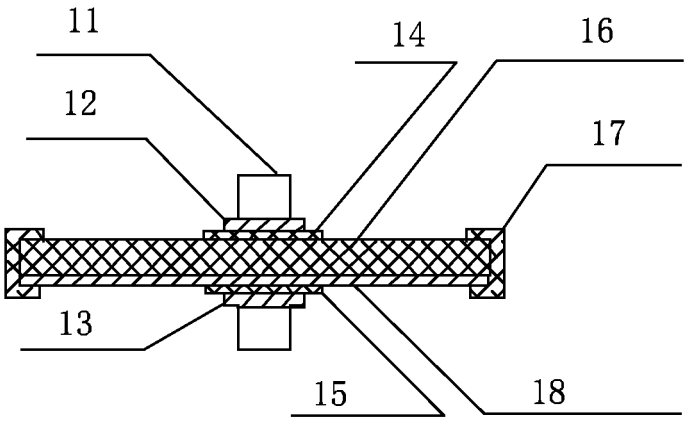

FIG. 3

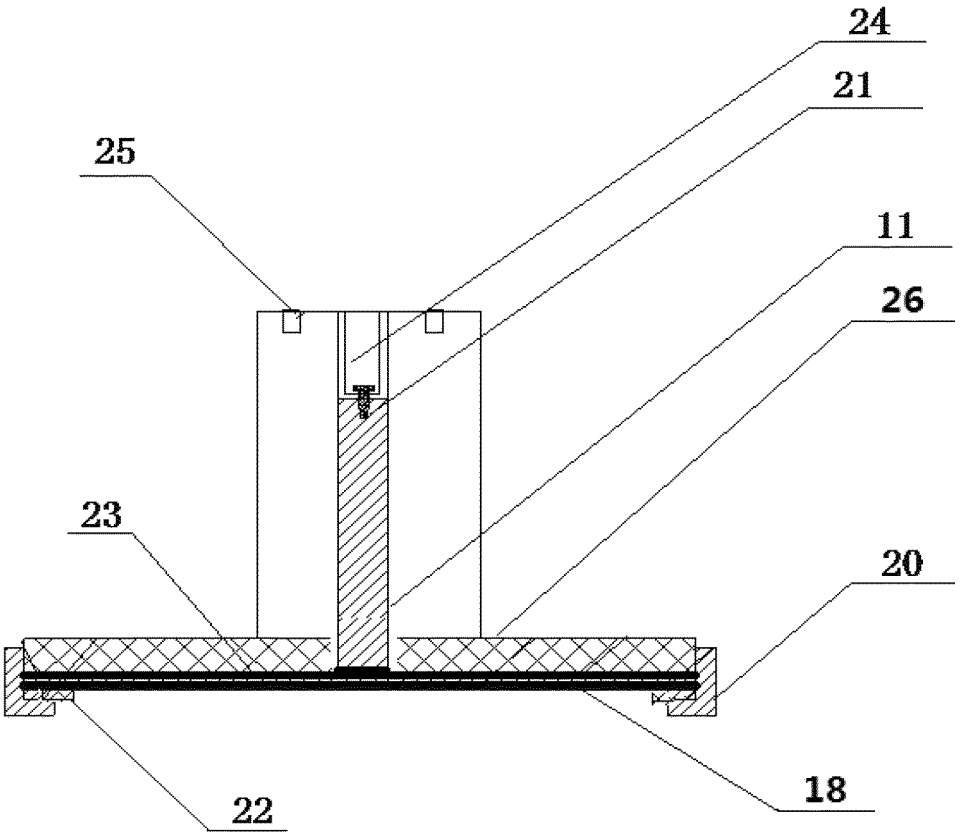

FIG. 4

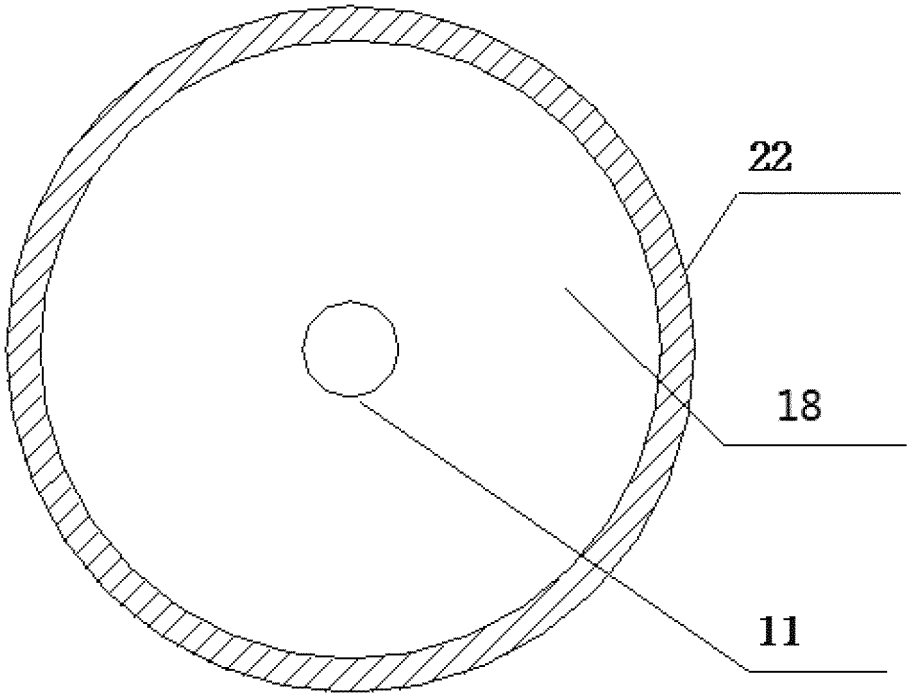

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2014/092599

A. CLASSIFICATION OF SUBJECT MATTER

C25D 17/00 (2006.01) i; C25D C25D 7/06 (2006.01) n; C25D 17/06 (2006.01) n
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C25D 17/00; C25D 7/06; C25D 17/06; C25D 17; C25D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

DWPI, SIPOABS, YEN, CNABS, CNTXT, EPTXT, USTXT, WOTXT, CNKI: deposit+, palted, plating, electrodeposit+, electroplat+, electrode, cathode, test, rota+, vertical, up, down, steel, band, belt, strip, disk, sheet, chip, plate, piece, champ+, hold+, jig, chuck+, cramp+, seal+, insulat+, screw, thread+, nut, teflon, polytetraflyoroethylene, PTFE, high speed, continuous

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 203639590 U (WARNER INTERNAT TONGLING ELECTRONIC MATERIAL CO LTD) 11 June 2014 (11.06.2014) figure 1	1
X	CN 2327701 Y (BAOSHAN IRON & STEEL) 07 July 1999 (07.07.1999) description, page 2, the twelfth line from the bottom to page 3, line 24, figures 1-4	1-6
A	CN 2327701 Y (BAOSHAN IRON & STEEL) 07 July 1999 (07.07.1999) the whole document	7-9
X	JP 3091966 B1 (YAMA-N YAMAMOTO SHIKENKI KK et al.) 25 September 2000 (25.09.2000) figures 1-3	1
X	JPH 0533196 A (TANAKA PRECIOUS METAL IND) 09 February 1993 (09.02.1993) description, embodiment, and figures 1-3	1

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 January 2015	09 February 2015
Name and mailing address of the ISA State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No. (86-10) 62019451	Authorized officer XU, Yan Telephone No. (86-10) 88996838

Form PCT/ISA /210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2014/092599

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JPH 0533196 A (TANAKA PRECIOUS METAL IND) 09 February 1993 (09.02.1993) the whole document	2-9
A	JP 3091966 B1 (YAMA-N YAMAMOTO MEKKI SHIKENKI KK et al.) 25 September 2000 (25.09.2000) the whole document	2-9
PX	CN 203960377 U (SHANGHAI MEISHAN IRON & STEEL) 26 November 2014 (26.11.2014) claims 5	1
A	CN 2618927 Y (BAOSHAN IRON & STEEL) 02 June 2004 (02.06.2004) the whole document	1-9
A	US 6159354 A (NOVELLUS SYSTEMS INC et al.) 12 December 2000 (12.12.2000) the whole document	1-9
A	CN 102257186 A (REPLISAURUS TECHNOLOGIES INC.) 23 November 2011 923.11.2011)the whole document	7-9

Form PCT/ISA /210 (continuation of second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2014/092599

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 203639590 U	11 June 2014	None	
CN 2327701 Y	07 July 1999	None	
JP 3091966 B1	25 September 2000	JP 2001003197 A	09 January 2001
JPH 0533196 A	09 February 1993	None	
CN 203960377 U	26 November 2014	None	
CN 2618927 Y	02 June 2004	None	
US 6159354 A	12 December 2000	WO 9925904 Al	27 May1999
		US 6193859 B1	27 February 2001
		WO 9925904 A9	16 eptember 1999
		WO 9925904 A8	12 August 1999
CN 102257186 A	23 November 2011	EP 2350357 Al	03 August 2011
		JP 2012508814 A	12 April 2012
		JP 5469178 B2	09 April 2014
		TW 201020344 A	01 June2010
		WO 2010054677 Al	20 May2010
		US 2011278162 Al	17 November 2011
		KR 20110088571 A	03 August 2011
		CN 102257186 B	15 October 2014

Form PCT/ISA /210 (patent family annex) (July 2009)