



(11) **EP 4 394 304 A1**

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

(43) Date of publication:
03.07.2024 Bulletin 2024/27

(51) International Patent Classification (IPC):
F28G 15/02 ^(2006.01) **F22B 37/52** ^(2006.01)

(21) Application number: **22899900.9**

(52) Cooperative Patent Classification (CPC):
F22B 37/52; F28G 15/02

(22) Date of filing: **06.07.2022**

(86) International application number:
PCT/CN2022/104046

(87) International publication number:
WO 2023/098080 (08.06.2023 Gazette 2023/23)

(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

(30) Priority: **03.12.2021 CN 202111468421**
03.12.2021 CN 202111474078

(71) Applicants:
• **Suzhou Nuclear Power Research Institute Co., Ltd.**
Suzhou, Jiangsu 215004 (CN)
• **China General Nuclear Power Group**
Futian District
Shenzhen
Guangdong 518000 (CN)
• **CGN Power Co., Ltd.**
Futian District
Shenzhen
Guangdong 518000 (CN)

(72) Inventors:
• **WU, Weirang**
Suzhou, Jiangsu 215004 (CN)
• **YU, Tong**
Suzhou, Jiangsu 215004 (CN)
• **SHE, Meiyu**
Suzhou, Jiangsu 215004 (CN)
• **CHENG, Zhifeng**
Suzhou, Jiangsu 215004 (CN)
• **FU, Dongliang**
Suzhou, Jiangsu 215004 (CN)
• **HE, Jian**
Suzhou, Jiangsu 215004 (CN)
• **CHEN, Shaoqing**
Suzhou, Jiangsu 215004 (CN)

(74) Representative: **Westphal, Mussnug & Partner,**
Patentanwälte mbB
Werinherstraße 79
81541 München (DE)

(54) **GUIDE RAIL MECHANISM, MOUNTING METHOD THEREFOR, STEAM GENERATOR CLEANING DEVICE HAVING GUIDE RAIL MECHANISM, AND CLEANING METHOD THEREFOR**

(57) Disclosed in the present invention is a guide rail mechanism suitable for cleaning a steam generator. The guide rail mechanism comprises a first guide rail and a second guide rail which are in insertion fit with each other, and a line guide rail arranged on the first guide rail and the second guide rail, wherein a plurality of positioning holes are provided in the line guide rail, the distance between adjacent positioning holes is the same as that between adjacent heat transfer tubes in the steam generator, and the positioning holes cooperate with a proximity sensor on a cleaning mechanism, so as to achieve translation positioning of the cleaning mechanism. The guide rail mechanism comprises a first clamping assembly and a second clamping assembly which are arranged on the

first guide rail and the second guide rail, and used for clamping a left portion and a right portion, respectively, of a spreader plate in the steam generator. According to the guide rail mechanism suitable for cleaning a steam generator in the present invention, the cleaning mechanism can equidistantly move below the whole-section guide rail mechanism, and the guide rail mechanism is convenient to mount, and is structurally stable after being mounted.

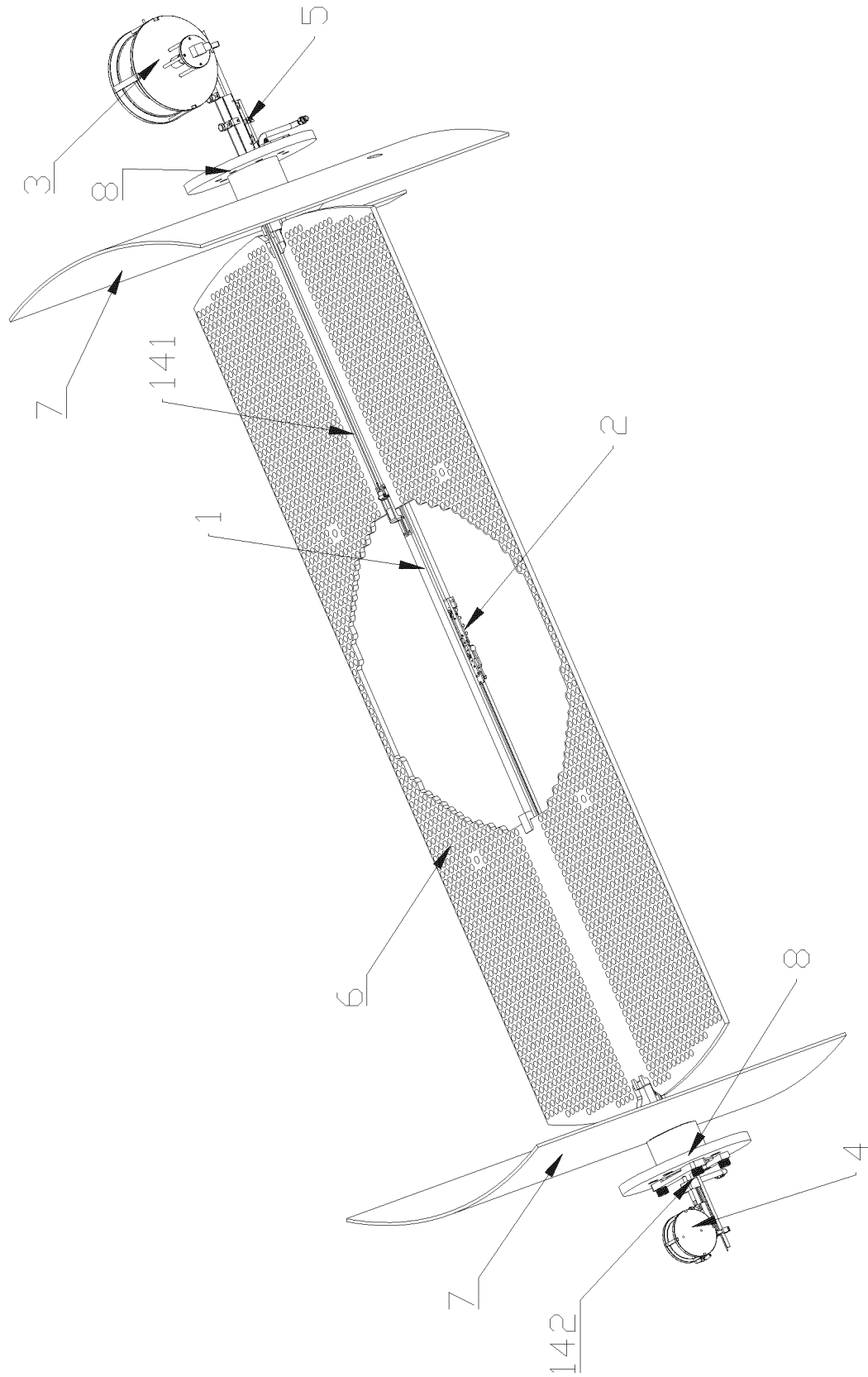


Figure 1

Description

FIELD

[0001] The invention relates to the field of steam generator cleaning technology, and more particularly to a guide rail mechanism in a high-efficiency and convenient steam generator cleaning device suitable for confined spaces, the method for installing the guide rail mechanism onto the divider plate of the steam generator, the steam generator cleaning device mounted with the guide rail mechanism and the cleaning method for steam generators with the cleaning device.

BACKGROUND

[0002] Steam generator is important for heat exchange between primary and secondary loops in a nuclear power plant, and has tens of thousands of tube bundles installed inside. During each shutdown maintenance of the nuclear power plant, the secondary side tube bundles of the steam generator must be cleaned.

[0003] In the existing steam generator cleaning technologies, restricted by the structure of steam generators, the handhole cleaning is generally realized by half-section cleaning, i.e. putting the cleaning tool into the vessel from handholes on both sides respectively for cleaning, and the cleaning tool must be transferred and installed between the two handholes. Meanwhile, a sectional type screwed rigid gun is used for cleaning, the length of the gun requires multiple adjustments to grow or shorten it to meet the cleaning requirement at different positions. Due to the confined space and high dose radiation in steam generator room, and the fact that the equipment must be transferred and the length of the gun must be increased or decreased multiple times for cleaning each steam generator, the equipment requires a long time for transferring and installation, and high doses are absorbed by operators.

[0004] In view of this defects, a patent with application No. 201710303338.8 and entitled A Full-section Type Cleaning Device For A Steam Generator And A Cleaning Method disclosed a cleaning device including a full-section guide rail for a steam generator, wherein nozzles are positioned step by step along the guide rail, and the air pincers of the actuator grip a rigid lance rod assembly, and the actuator drives the lance rod assembly to translate the one or more spacing intervals between heat transfer tubes in a screw drive manner. In this way, the gun has to be lengthened twice, and when the gun is lengthened to a longer length (about 3m), the gun assembly becomes a cantilever structure, and there is a certain potential risk of fracture during operation. Additionally, due to the accumulation of error of the lead screw assembly translating, the clamping position of the gun assembly must be adjusted frequently during cleaning, to make sure the jet flow from the nozzle is aligned with the gap between the tubes. Restricted by the installation

space, the flat guide rail is connected in three sections and installed by using an extension of the guide rail, so it is difficult to install the guide rail due to the insufficient rigidity of the structure at the connection of the guide rail.

SUMMARY

[0005] On that account, to overcome the defects of the existing technologies, this invention is intended to provide an improved guide rail mechanism suitable for steam generator cleaning, which allows rapid and solid installation of the guide rail mechanism in a single full-stroke, and precise moving and positioning of the cleaning mechanism.

[0006] To achieve the above goals, this invention uses the following technical solution:

[0007] A guide rail mechanism suitable for cleaning a steam generator, comprising a first guide rail and a second guide rail which are fitted to each other by inserting, and a linear rail provided on both the first guide rail and the second guide rail; several positioning holes are provided in the linear rail; the distance between adjacent positioning holes is the same as the distance between adjacent heat transfer tubes in the steam generator; the positioning holes are used to cooperate with the positioning holes for translating positioning of the cleaning mechanism; the guide rail mechanism comprises a first clamping assembly and a second clamping assembly on first guide rail and second guide rail respectively for clamping the left and right parts of the divider plate in the steam generator.

[0008] The first guide rail and the second guide rail are connected by axle hole fitting, and fixed to the divider plate by fixed blocks and moving blocks, the linear rail and the positioning holes are machined under guide rail, the first guide rail (long) and the second guide rail (short) are fitted to ensure smooth connection. Furthermore, plunger holes are machined above the guide rail.

[0009] The guide rail mechanism is installed under the divider plate of the steam generator, a linear rail is machined at the bottom of the guide rail for moving cleaning mechanism, and a plurality of positioning holes spaced apart and equally spaced from the heat transfer tubes are machined in the linear rail. The cleaning mechanism can travel along the linear rail, and a proximity sensor is centrally mounted on the top of the cleaning mechanism. The cleaning mechanism is moved equidistantly under the guide rail mechanism by means of proximity sensor and positioning holes in the linear rail.

[0010] Based on some preferred embodiments of this invention, wherein the first clamping assembly comprises a first fixed block, a first moving block, and a first clamping assembly for driving the first moving block close to the first fixed block; the second clamping assembly comprises a second fixed block, a second moving block, and a second clamping assembly for driving the first guide rail and the second guide rail to insert them into each other. The first fixed block, the first moving block, the first clamp-

ing assembly and the second fixed block are located on one of the first guide rail and the second guide rail, and the second moving block and the second clamping assembly are located on the other one of the first guide rail and the second guide rail.

[0011] Based on some preferred embodiments of this invention, wherein the first clamping assembly comprises a first slider, a tensioning guide rail and a first lead screw; one end of the first lead screw is connected to the first fixed block by a rotary joint, and the other end of the first lead screw runs through the first slider; a clamping section is provided on the lower part of the first slider, and a first sliding groove is provided at each side of the first guide rail, the clamping section is accommodated within the first sliding groove; a clipping groove is provided in the tensioning guide rail, and the upper portion of the first slider is snapped into the clipping groove; the movement of the tensioning guide is achieved by moving the first slider in the clipping groove.

[0012] Based on some preferred embodiments of this invention, wherein a traction frame is provided at one end of the tensioning guide rail close to the first slider, and the traction frame is socketed to the first moving block; a second sliding groove corresponding to the first moving block is provided in the first guide rail, and a second clamping section corresponding to the second sliding groove is provided on the lower portion of the first moving block, the second clamping section is accommodated in the second sliding groove.

[0013] Based on some preferred embodiments of this invention, wherein a hook plate extending downwardly is provided at one end of the traction frame away from the tensioning guide rail; the hook plate is used to affix to and hook the first moving block.

[0014] Based on some preferred embodiments of this invention, wherein a positioning block is provided on the tensioning guide rail; the positioning block is located at one end of the clipping groove away from the traction frame, and the positioning block is used to limit the movement of the first slider; positioning blocks are provided in the clamping groove on each side of the tensioning guide, and the positioning blocks are integrated with the tensioning guide rail; the first slider is provided with a groove corresponding to the positioning block, and when the first slider is sliding in the clipping groove, the positioning block is clipped in the groove of the first slider, thereby limiting the movement of the first slider and preventing the first slider from running off the tensioning guide rail.

[0015] Based on some preferred embodiments of this invention, wherein the second clamping assembly comprises fasteners, a second slider, a second lead screw and an installation block; one end of the second lead screw is connected to the installation block by a rotary joint, and the other end of the second lead screw runs through the second slider; a limiting part is provided in the lower portion of the second slider, and a limiting groove is provided on each side of the second guide rail, the limiting part is accommodated in the limiting groove;

the fasteners and the installation block are used to fix the second clamping assembly on the flange of the handhole of the steam generator.

[0016] Based on some preferred embodiments of this invention, wherein the second clamping assembly comprises a mounting flange; the mounting flange is used to match with the handhole flange of the steam generator to realize the installation of the guide rail mechanism; the second sliders are slidable on both sides of the second guide rail by means of the limit part and the limiting groove mating like a dovetail-slot; one end of the lead screw is connected to the installation block and can rotate freely; the mounting flange is connected to the flange of the handhole by the fasteners such as bolts; the rotation of the second lead screw push the second slider to move, which drives the second guide rail to insert into the first guide rail, thereby realise the fixing of the short rail and the connection of the long rail.

[0017] Based on some preferred embodiments of this invention, wherein a camera is provided at one end of the tensioning guide rail close to the traction frame, and the camera is used for visually aided installation; a wireway is provided in the tensioning guide rail for accommodating a cable of the camera.

[0018] Based on some preferred embodiments of this invention, wherein an inserter is provided at one end of the second guide rail, and a socket is provided at one end of the first guide rail; the inserter is accommodated within the socket to realize the connection between the first guide rail and the second guide rail.

[0019] This invention also provides an installation method for the above mentioned guide rail mechanism, including the following steps:

a) Put the first guide rail into the steam generator through a handhole, and hang it on a divider plate of the steam generator by the first fixed block and the second fixed block;

b) Shorten the distance between the first slider and the first moving block by the tensioning guide rail and lock it, so that the first moving block is closely attached to the divider plate to realize the fixation of the first guide rail;

c) Put the second guide rail into the steam generator through the other handhole; hang the second moving block on the divider plate, and insert the second guide rail into the first guide rail for connection;

d) Install the second clamping assembly so that one end of the second guide rail is continuously inserted in one end of the first guide rail to achieve the connection between the first guide rail and the second guide rail and the fixation between the guide rail mechanism and the divider plate.

[0020] This invention also provides a steam generator

cleaning device, comprising a aforesaid guide rail mechanism, and a cleaning mechanism, a traction mechanism, a high-pressure hose reel mechanism and a traction rope reel mechanism; a proximity sensor is provided in the cleaning mechanism to cooperate with the positioning holes for translating positioning of the cleaning mechanism, so that a nozzle in the cleaning mechanism is aligned midway between adjacent heat transfer tubes; the traction mechanism comprises a high-pressure hose and a traction rope are provided on both sides of the cleaning mechanism respectively; the high-pressure hose is used to supply water to the cleaning mechanism; the high-pressure hose reel mechanism is used to wind the high-pressure hose to move the cleaning mechanism; the steam generator cleaning device of the present invention can achieve fast and stable installation of the guide rail mechanism, and the positioning holes in the linear rail set below the guide rail and the proximity sensor in the cleaning mechanism are combined to sense the position and drive turntable mechanisms on both sides, resulting in the precise movement and positioning of the cleaning mechanism.

[0021] The steam generator cleaning device of the nuclear power plant of the present invention, with the assistance of the sensor component, the cleaning mechanism is able to achieve the precise positioning required for cleaning, and to ensure the cleaning effect while the cleaning efficiency is better. The first guide rail and the second guide rail are connected by axle hole fitting, and fixed to the divider plate by fixed blocks and moving blocks, the linear rail and the positioning holes are machined under guide rail, the first guide rail (long) and the second guide rail (short) are fitted to ensure smooth connection. Furthermore, plunger holes are machined above the guide rail.

[0022] The guide rail mechanism is installed under the divider plate of the steam generator, a linear rail is machined at the bottom of the guide rail for moving cleaning mechanism, and a plurality of positioning holes spaced apart and equally spaced from the heat transfer tubes are machined in the linear rail. The cleaning mechanism can travel along the linear rail, and a proximity sensor is centrally mounted on the top of the cleaning mechanism. one end of the cleaning mechanism is connected to the traction rope reel, and the other end is connected to the high-pressure hose mechanism, and the cleaning mechanism is pulled to move at equal steps under the whole-section type guide rail mechanism, by cooperative control of the traction rope reel and the high-pressure hose reel mechanism, the auxiliary roller mechanism is provided to limit the moving route of the high-pressure hose, and ensure the reliable movement of the reel. The entire cleaning process is intelligent and no manual intervention or adjustment is required.

[0023] Based on some preferred embodiments of this invention, wherein the cleaning mechanism comprises an auxiliary roller mechanism for the support of the high-pressure hose; the auxiliary roller mechanism comprises

a fixed frame, a moving frame moving relatively to the fixed frame, an adjusting assembly provided between the fixed frame and the moving frame, and limiting rollers provided on the moving frame or the fixed frame; the limiting rollers on the moving frame and the fixed frame are on each side of the high-pressure hose respectively to limit the movement of the high-pressure hose.

[0024] Based on some preferred embodiments of this invention, wherein the auxiliary roller mechanism comprises a lock-pin assembly and a mounting rack assembly; the adjusting assembly comprises an adjusting bolt and an elastic element between the fixed frame and the moving frame; the limiting rollers comprise fixed group limit rollers in the fixed frame and moving group limit rollers in the moving frame; the high-pressure hose runs between the fixed group limit rollers and the moving group limit rollers. In order to facilitate installation, the clearance between the fixed group limit rollers and the moving group limit rollers can be adjusted by adjusting the adjusting bolt and the elastic element, so as to ensure that the high-pressure hose contacts the rollers disposed on both sides, and then it is locked by the lock-pin assembly after the adjustment is completed. The mounting rack assembly comprises a mounting rack and a third spring plunger located on the mounting rack. A guide rail groove matching the profile of the first guide rail is provided in the upper portion of the fixed frame, and the fixed frame is socketed to the first guide rail by the guide rail groove, as well as, the fixed frame can be quickly mounted and fixed to the long guide rail by means of an axle-bore fit between the spring plunger located on the mounting rack and the plunger hole.

[0025] Based on some preferred embodiments of this invention, wherein the cleaning mechanism comprises a frame, a nozzle carrier, a cable holder and rollers, and a first driving assembly for driving the nozzle carrier to rotate; the nozzle carrier, the cable holder and the plurality of rollers are provided on the frame; the proximity switch is provided on the top of the frame and cooperates with the positioning holes in the linear rail; the plurality of rollers are provided on both sides of the linear rail to allow the cleaning mechanism to move along the linear rail.

[0026] Based on some preferred embodiments of this invention, wherein the cleaning mechanism also includes a camera, and the first driving assembly comprises a first motor and a gear set. The first motor drives the gear set to rotate, which in turn drives the nozzle carrier to rotate. The nozzle is installed in the nozzle carrier. The high-pressure hose is connected to one end of the frame, and the other end of the frame is connected to cable and the traction rope. The cable is secured by the cable holder. rollers in two groups are installed on the upper face of the frame to hold the wire rail, and the proximity sensor is installed and centred on the upper face of the frame, corresponding to the positioning hole.

[0027] Based on some preferred embodiments of this invention, wherein the high-pressure hose reel mechanism comprises a high-pressure hose reel, a first reel

frame, a hose connector outlet, a rotary joint, a first installation assembly, and a second driving assembly for driving the high-pressure hose reel to rotate; a through hole is provided in the high-pressure hose reel; one end of the high-pressure hose is connected to the nozzle carrier, and the other end of the high-pressure hose is connected to the rotary joint after passing through the through hole and the hose connector outlet; the first installation assembly is used to secure the high-pressure hose reel mechanism on the first guide rail.

[0028] Based on some preferred embodiments of this invention, wherein the first installation assembly comprises a first mounting plate, a first spring plunger and a transition wheel assembly; a first guide rail groove matching the profile of the first guide rail is provided in the first mounting plate; the high-pressure hose is wound around the high-pressure hose reel, and passes through the through hole in the reel to reach the hose connector outlet, then be coupled to the rotary joint, the other end of the rotary joint is connected to a high-pressure hose of a pump, and the other end of the high-pressure hose is connected to the cleaning mechanism, the first mounting plate is located under the reel frame and connected to the first long guide rail by a first spring plunger provided on the first mounting plate; the second driving assembly comprises a second motor and a coupling; the second motor drives the high-pressure hose reel to retract and release the high-pressure hose; and the second motor is connected to the spool of the reel through the elastic coupling; and the coupling can be disconnected for manual retract/release or connected for automatic retract/release. The transition wheel assembly comprises a transition frame and a transition wheel in the transition frame, the transition wheel is used to support the high-pressure hose, and be used to limit the movement of the high-pressure hose before it enters the reel, thereby ensuring the normal operation of the reel.

[0029] Based on some preferred embodiments of this invention, wherein the traction rope reel mechanism comprises a traction rope reel, a second reel frame, a second installation assembly, and a third driving assembly for driving the traction rope reel to rotate; a limiting wheel assembly is provided in the second installation assembly, which comprises a limiting wheel frame, and a first limiting wheel, a second limiting wheel and a third limiting wheel which are arranged in sequence in the limiting wheel frame; a first limiting opening for passing through the traction rope is formed between the first limiting wheel and the second limiting wheel, and a second limiting opening for passing through the cable connected to the cleaning mechanism is formed between the second limiting wheel and the third limiting wheel. The cable is used for signal and power transmission to the motor and camera in the cleaning mechanism.

[0030] Based on some preferred embodiments of this invention, wherein the second installation assembly, which is similar to the first installation assembly, comprises a second mounting plate and a second spring

plunger; a second track groove matching the shape of the second guide rail is provided in the second mounting plate. The third driving assembly comprises third motor. One end of the traction rope is pulled through and wound around the traction rope reel, the traction rope reel is installed in the traction rope reel frame, and driven by third motor for winding; the other end of the traction rope is connected to a cleaning robot. The second mounting plate is installed under the traction rope reel frame and can be connected to the short guide rail. The second spring plunger is used for quick installation and limiting. The first limiting wheel and the second limiting wheel in the limiting wheel assembly allow position adjustment in vertical direction to prevent cable from running off. A tension sensor is mounted on the first limit wheel.

[0031] Based on some preferred embodiments of this invention, wherein an inserter is provided at one end of the second guide rail, and a socket is provided at one end of the first guide rail; the inserter is accommodated within the socket to realize the connection between the first guide rail and the second guide rail; the high-pressure hose reel mechanism is provided on the end of the first guide rail away from the socket; the auxiliary roller mechanism is provided between the high-pressure hose reel mechanism and the socket; the traction rope reel mechanism is provided on the end of second guide rail away from the inserter; the second clamping assembly is provided between the traction rope reel mechanism and the inserter.

[0032] This invention also provides a cleaning method for cleaning steam generators using the above mentioned cleaning device, which includes the following steps:

- 1) Install the guide rail mechanism on the divider plate of the steam generator by the first clamping assembly and the second clamping assembly;
- 2) Connect the high-pressure hose to the cleaning mechanism, and move the cleaning mechanism to the starting position of the linear rail;
- 3) Connect the cable of the cleaning mechanism to the control system; connect the water inlet of the high-pressure hose reel mechanism to the water outlet of the pump;
- 4) Start the cleaning device by a control system; the high-pressure hose reel mechanism starts to rotate and pull the cleaning device to move until the proximity sensor senses the first positioning hole, and the high pressure pipe carousel mechanism stops the pulling action; then start the nozzle on the cleaning mechanism and start to clean the area between the heat transfer tubes;
- 5) When the cleaning of the area between tubes is finished, restart the high-pressure hose reel mech-

anism to rotate until the proximity sensor senses the positioning hole again; restart the nozzle on the cleaning mechanism and start to clean the area between the heat transfer tubes;

6) Repeat Step 5) to complete the cleaning of all areas between tubes, then remove all parts of the cleaning device and take out the parts from the hand-holes, and the cleaning is completed.

[0033] Thanks to the above technical solution, compared with the existing technologies, this invention has the following beneficial effects: the guide rail mechanism of this invention, which is suitable for cleaning steam generator, allows rapid and solid installation of the guide rail mechanism in a single full-stroke, to ensure precise translating and positioning of the cleaning mechanism under the whole-section type guide rail mechanism. As to a steam generator cleaning device comprising the guide rail mechanism, by the cooperative control of the high-pressure hose reel mechanism and traction rope reel mechanism, the cleaning mechanism moves at equal steps under the whole-section type guide rail mechanism, with moving distance achieved by the reel assembly driven by the proximity switch and the sensing signal of the positioning holes machined under the guide rail; it is not required to adjust the length of the cleaning gun; the alignment of the jet flow is monitored in real time.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] To describe the technical solution in the embodiments of this invention more clearly, the drawings to be used in the description of the embodiments are introduced briefly as follows. Obviously, the following drawings just refer to some embodiments of this invention, and for general technicians in this field, other drawings can be obtained based on these drawings without any creative work.

FIG. 1 shows a 3-D diagram of an installed cleaning device in a preferred embodiment of this invention;

FIG.2 shows a front view of the cleaning device in the preferred embodiment of this invention;

FIG.3 shows a 3-D diagram of the cleaning device in the preferred embodiment of this invention;

FIG.4 shows a schematic diagram of the guide rail mechanism in the cleaning device in the preferred embodiment of this invention;

FIG.5 shows an enlarged view of Part I in FIG.3;

FIG.6 shows an enlarged view of Part II in FIG.3;

FIG.7 shows an enlarged view of Part III in FIG.3;

FIG.8 shows an enlarged view of Part IV in FIG.3;

FIG.9 shows a 3-D diagram of second clamping assembly in the cleaning device in the preferred embodiment of this invention;

FIG.10 shows a 3-D diagram of second clamping assembly in the cleaning device in the preferred embodiment of this invention from another perspective;

FIG.11 shows a 3-D diagram of the cleaning mechanism in the cleaning device in the preferred embodiment of this invention;

FIG.12 shows a 3-D diagram of the cleaning mechanism in the cleaning device in the preferred embodiment of this invention from another perspective;

FIG.13 shows a 3-D diagram of the high-pressure hose reel mechanism in the cleaning device in the preferred embodiment of this invention;

FIG.14 shows a 3-D diagram of the auxiliary roller mechanism in the cleaning device in the preferred embodiment of this invention;

FIG.15 shows a 3-D diagram of the auxiliary roller mechanism in the cleaning device in the preferred embodiment of this invention from another perspective;

FIG.16 shows a 3-D diagram of the traction rope reel mechanism in the cleaning device in the preferred embodiment of this invention;

FIG.17 shows a 3-D diagram of the limiting wheel assembly of the traction rope reel mechanism in the cleaning device in the preferred embodiment of this invention;

In the drawings, 1. guide rail mechanism; 11. first guide rail; 12. second guide rail; 131. first fixed block; 132. first moving block; 133. second fixed block; 134. second moving block; 141. first clamping assembly; 1411. first slider; 1412. tensioning guide rail; 1413. first lead screw; 1414. first sliding groove; 1415. clipping groove; 1416. traction frame; 1417. second sliding groove; 1418. wireway; 1419. first camera; 142. second clamping assembly; 1421. fasteners; 1422. mounting flange; 1423. second slider; 1424. second lead screw; 1425. installation block; 1426. third sliding groove; 1427. limiting groove; 1428. positioning block; 15. linear rail; 16. positioning holes;

2. cleaning mechanism; 21. frame; 22. nozzle carrier; 23. nozzle; 24. first motor; 25. gear set; 26. second camera; 27. proximity sensor; 28. cable holder; 29. high-pressure hose; 210. cable; 211. traction rope;

212 rollers;

3. high-pressure hose reel mechanism; 31. second motor; 32. high-pressure hose reel; 33. first reel frame; 34. rotary joint; 35. first mounting plate; 351. first guide rail groove; 36. transition wheel assembly; 37. hose connector outlet; 38. first spring plunger;

4. traction rope reel mechanism; 41. third motor; 42. second reel frame; 43. traction rope reel; 44. second spring plunger; 45. second mounting plate; 451. second guide rail groove; 46. limiting wheel assembly; 461. first limiting wheel; 462. second limiting wheel; 463. third limiting wheel; 464. limiting wheel frame; 465. connecting rod; 466. adjusting groove;

5. auxiliary roller mechanism; 511. fixed frame; 512. moving frame; 521. fixed group limit rollers; 522. moving group limit rollers; 53. bolt hole; 54. lock-pin assembly; 55. mounting rack; 56. guide rail groove; 57. connecting plate; 58. third spring plunger;

6. divider plate; 7. steam generator barrel; 8. hand-hole.

DESCRIPTION OF THE EMBODIMENTS

[0035] To help the personnel in this technical field to better understand the technical solution of this invention, the technical solution in the embodiments of this invention is described clearly and completely as follows by making reference to the drawings in the embodiments of this invention. Obviously, the described embodiments are just a part of the embodiments of this invention and not all of it. Any other embodiments obtained by general technicians in this field, without any creative work, on the basis of the embodiments in this invention, shall be included in the protected scope of this invention.

[0036] The steam generator cleaning device of this embodiment as shown in FIGs. 1-17 comprises a guide rail mechanism 1, a cleaning mechanism 2, a traction mechanism, a high-pressure reel mechanism 3, a traction rope reel mechanism 4 and an auxiliary roller mechanism 5 for supporting a high-pressure hose 29; the traction mechanism comprises a high-pressure hose 29 and a traction rope 211 are provided on both sides of the cleaning mechanism 2 respectively; the high-pressure hose 29 supplies water to the cleaning mechanism 2; the high-pressure hose reel mechanism 3 is used to wind the high pressure hose 29 to move the cleaning mechanism 2.

[0037] By cooperative control of the high-pressure hose reel mechanism 3 and the traction rope reel mechanism 4, the cleaning mechanism 2 moves at equal steps under the whole-section type guide rail mechanism 1. The displacement of the cleaning mechanism 2 is achieved by driving the turntable assembly using a sensing signal generated by a proximity switch proximity sensor in conjunction with positioning holes 16 machined in

a linear rail set underneath guide rails. Additionally, the second camera 26 is used to visualise and monitor the water flow, thereby meeting the requirement of high-pressure jet cleaning between tubes bundles and ensure good cleaning effect with a higher cleaning efficiency. The cleaning device has higher translating precision, better cleaning effect, higher intelligent level, less rigid gun lengthening/shortening processes and higher cleaning efficiency; the camera monitors the jet flow's alignment with the area between tubes.

[0038] The structure of each component is detailed as follows:

(1) The guide rail mechanism 1

[0039] The guide rail mechanism 1 comprises a first guide rail 11 and a second guide rail 12 which are fitted by inserting into each other, a linear rail 15 provided on both the first guide rail 11 and the second guide rail 12, a first clamping assembly and a second clamping assembly respectively for clamping the left and right parts of the divider plate 6 in the steam generator; the linear rail 15 is provided with several positioning holes 16. In this embodiment, the positioning holes 16 are round. The distance between adjacent positioning holes 16 is the same as the distance between adjacent heat transfer tubes in the steam generator, so that a nozzle 23 in the cleaning mechanism 2 is aligned to the center between adjacent heat transfer tubes; the cleaning mechanism 2 is provided with a proximity sensor 27, which is used to cooperate with the positioning holes 16 for translating positioning of the cleaning mechanism 2.

[0040] The second guide rail 12 is provided with an inserter on one end, and the first guide rail 11 is provided with a socket on one end; the inserter is inserted in the socket to realize the connection between the first guide rail 11 and the second guide rail 12, i.e. the long guide rail and the short guide rail are connected by axle hole fitting, and fixed on the divider plate 6 by the clamping assemblies. The inserter and the socket are designed as corresponding trapezoidal structures for easy insertion and support. The overall length of the first guide rail 11 and the second guide rail 12 after insertion and fixation is greater than the length of the divider plate 6, i.e. the ends of the first guide rail 11 and the second guide rail 12 are protruding from the flange face of the hand hole 8, which on the one hand facilitates mounting of the first guide rail 11 and the second guide rail 12 to the divider plate 6, and on the other hand is used for mounting the corresponding reel mechanism. The linear rail 15 and the positioning holes 16 are machined under the guide rails; the long guide rail and the short guide rail are fitted fit together and butt up flat.

[0041] The first clamping assembly comprises a first fixed block 131, a first moving block 132 and a first clamping assembly 141 for driving the first moving block 132 close to the first fixed block 131. The first clamping assembly 141 comprises a first slider 1411, a tensioning

guide rail 1412 and a first lead screw 1413, wherein one end of the first lead screw 1413 is connected to the first fixed block 131 by a rotary joint, and the other end of the first lead screw 1413 runs through the first slider 1411. A clamping section is provided on the lower part of the first slider 1411, and a first sliding groove 1414 is provided at each side of the first guide rail 11, the clamping section is accommodated within the first sliding groove 1414. A clipping groove 1415 is provided in the tensioning guide rail 1412, and the upper portion of the first slider 1411 is snapped into the clipping groove 1415; by the movement of the first slider 1411 within the clipping groove 1415, when the first slider 1411 resists the end of the clipping groove 1415, the movement of the tensioning guide rail 1412 is realised, which in turn pulls the first moving block towards the first fixed block. A traction frame 1416 is provided at one end of the tensioning guide rail 1412 near the first slider 1411, and the traction frame 1416 is socketed to the first moving block 132. A second sliding groove 1417 corresponding to the first moving block 132 is provided in the first guide rail 11, and a second clamping section corresponding to the second sliding groove 1417 is provided on the lower portion of the first moving block 132, the second clamping section is accommodated in the second sliding groove 1417.

[0042] As shown in FIG. 5, in this embodiment, to make sure the tensioning guide rail 1412 pulls the first moving block 132 smoothly, positioning blocks 1428 are provided on the tensioning guide rail 1412, and grooves are correspondingly provided in the first slider 1411, any one of the positioning blocks 1428 is located at an end of the clipping groove 1415 away from the traction frame 1416, and the positioning block 1428 is used to limit the movement of the first slider. The positioning blocks 1428 are provided in the clipping grooves 1415 located on both sides of the tensioning guide rail 1412, the positioning blocks 1428 are integrated with the tensioning guide rail 1412, and the first slider 1411 is provided with a groove corresponding to the positioning block 1428, when the first slider 1411 is sliding in the clipping groove, the positioning block 1428 is clipped in the groove of the first slider 1411, thereby limiting the movement of the first slider 1411 and prevent the first slider 1411 from running off the tensioning guide rail 1412.

[0043] In this embodiment, a first camera 1419 is provided at one end of the tensioning guide 1412 near the traction frame 1416, which is used to provide visual assistance when the traction frame is installed in register with the first moving block, thereby facilitating quick installation. The tensioning guide rail 1412 is provided with a wireway 1418 to accommodate the cable of the first camera 1419. In this embodiment, a downward extended hook plate is provided on the end of the traction frame 1416 away from the tensioning guide rail 1412, and the hook plate is used to affix to and hook the first moving block 132 to prevent the traction frame 1416 from running off the first moving block 132, as shown in FIG. 6.

[0044] The second clamping assembly comprises a

second fixed block 133, a second moving block 134 and a second clamping assembly 142 for driving the first guide rail 11 and the second guide rail 12 to insert them into each other. The first fixed block 131, the first moving block 132, the first clamping assembly 141 and the second fixed block 133 are located on the first guide rail 11, and the second moving block 134 and the second clamping assembly 142 are located on the second guide rail 12, the second moving block 134 is hung on the divider plate to provide a supporting point when the second guide rail 12 is installed. A third sliding groove 1426 for moving the second moving block 134 is provided on each side of the second guide 12. The second clamping assembly 142 comprises fasteners 1421, a second slider 1423, a second lead screw 1424, a installation block 1425 and a mounting flange 1422. One end of the second lead screw 1424 is connected to the installation block 1425 by a rotary joint, and the other end of the second lead screw 1424 runs through the second slider 1423. A limiting part is provided in the lower portion of the second slider 1423, and a limiting groove 1427 is provided in each side of the second guide rail 12, the limiting part is accommodated in the limiting groove 1427. The fasteners 1421 and the installation block 1425 are used to fix the second clamping assembly 142 on the flange of the handhole 8 of the steam generator. In some embodiments, the mounting flange 1422 and the installation block 1425 may also be of one piece construction.

[0045] The mounting flange 1422 matches with the flange of the handhole 8 in the barrel of the steam generator barrel 7 for installation. The second sliders 1423 are slidable on both sides of the second guide rail 12 by means of the limit part and the limiting groove 1427 like a dovetail-slot. One end of the second lead screw 1424 is connected to the installation block 1425 and can rotate freely. The mounting flange 1422 is connected to the flange of the handhole 8 by the fasteners 1421 such as bolts. The rotation of the second lead screw 1424 drives the second slider 1423 to move, and when the second slider 1423 reaches the end of the limiting groove 1427, the second slider 1423 inserts the second guide rail 12 into the first guide rail 11 to secure the short guide rail and connect to the long guide rail.

[0046] The high-pressure hose reel mechanism 3 is provided at the end of the first guide rail 11 away from the socket. The auxiliary roller mechanism 5 is provided between the high-pressure hose reel mechanism 3 and the first clamping assembly 141. The traction rope reel mechanism 4 is provided at the end of the second guide rail 12 away from the inserter, and the second clamping assembly 142 is provided between the traction rope reel mechanism 4 and the inserter.

[0047] With the assistance of the sensor assembly, the cleaning mechanism 2 of the steam generator cleaning device of a nuclear power plant in this embodiment is able to achieve the precise positioning required for cleaning, and guarantee the cleaning effect with better cleaning efficiency. The first guide rail 11 and the second guide

rail 12 are connected by axle hole fitting, and fixed to the divider plate 6 by fixed blocks and moving blocks. And the linear rail 15 and the positioning holes 16 are machined under guide rail, the first guide rail (long) and the second guide rail (short) are fitted to ensure smooth connection. Furthermore, plunger holes are machined above the guide rail.

[0048] The guide rail mechanism 1 is installed under the divider plate 6 of the steam generator, a linear rail 15 is machined at the bottom of the guide rail for moving cleaning mechanism 2, and a plurality of positioning holes 16 spaced apart and equally spaced from the heat transfer tubes are machined in the linear rail 15. The cleaning mechanism 2 can travel along the linear rail 15, and a proximity sensor 27 is centrally mounted on the top of the cleaning mechanism 2. One end of the proximity sensor 27 is connected to the reel of the traction rope 211 and the other end of the proximity sensor 27 is connected to the high-pressure hose reel mechanism 3. Through the collaborative control of the reel of the traction rope 211 and high-pressure hose reel mechanism 3, the cleaning mechanism 2 can be pulled and moved isometrically under the guide rail mechanism 1. The auxiliary roller mechanism 5 is provided to limit the moving route of the high-pressure hose 29, and ensure the reliable movement of the reel.

(2) The cleaning mechanism 2

[0049] The cleaning mechanism 2 comprises a frame 21, a nozzle carrier 22 and a cable holder 28 provided on the frame 21, rollers 212, a first driving assembly for driving the nozzle carrier 22 to rotate, and a second camera 26, wherein all components are installed on the frame 21. The proximity switch is provided on the top of the frame 21 and cooperates with the positioning holes 16 in the linear rail 15. The several rollers 212 are provided on both sides of the linear rail 15 to allow the cleaning mechanism 2 to move along the linear rail 15.

[0050] The first driving assembly comprises a first motor 24 and a gear set 25. The first motor 24 drives the gear set 25 to rotate, which in turn drives the nozzle carrier 22 to rotate. The nozzle 23 is installed in the nozzle carrier 22. The high-pressure hose 29 is connected to one end of the frame 21, and the other end of the frame 21 is connected to cable 210 and the traction rope 211. The cable 210 is secured by the cable holder 28. 4 rollers 212 in two groups are installed on the upper face of the frame 21 to hold the wire rail 15, and the proximity sensor 27 is installed and centred on the upper face of the frame 21, corresponding to the position of the positioning hole 16.

(3) The high-pressure hose reel mechanism 3

[0051] The high-pressure hose reel mechanism 3 comprises a high-pressure hose reel 32, a first reel frame 33, a hose connector outlet 37, a rotary joint 34, a first instal-

lation assembly, and a second driving assembly for driving the high-pressure hose reel 32 to rotate. The high-pressure hose reel 32 is provided with a through hole, and one end of the high-pressure hose 29 is connected to the nozzle carrier 22, and the other end is connected to the rotary joint 34 after passing through the through hole and the hose connector outlet 37. The first installation assembly is used to fix the high-pressure hose reel mechanism 3 on the first guide rail 11.

[0052] The first installation assembly comprises a first mounting plate 35, a first spring plunger 38 and a transition wheel assembly 36. A first guide rail groove 351 matching the profile of the first guide rail 11 is provided in the first mounting plate 35. The high-pressure hose 29 is wound around the high-pressure hose reel 32, wherein passes through the through hole in the reel to reach the hose connector outlet 37, then be coupled to the rotary joint 34, the other end of the rotary joint 34 is connected to a high-pressure hose 29 of a pump, and the other end of the high-pressure hose 29 is connected to the cleaning mechanism 2. The first mounting plate 35 is provided under the reel frame 33 and connected to the first guide rail (long) through the first spring plunger 38 on the first mounting plate 35. The second driving assembly comprises a second motor 31 and a coupling. The second motor 31 drives the high-pressure hose reel 32 to retract and release the high-pressure hose 29. The second motor 31 is connected to the spool of the reel through the elastic coupling, and the coupling can be disconnected for manual retract/release or connected for automatic retract/release. The transition wheel assembly 36 comprises a transition frame and a transition wheel in the transition frame, the transition wheel is used to support the high-pressure hose 29, and be used to limit the movement of the high-pressure hose 29 before it enters the reel, thereby ensuring the normal operation of the reel.

(4) The traction rope reel mechanism 4

[0053] The traction rope reel mechanism 4 comprises a traction rope reel 43, a second reel frame 42, a second installation assembly, and a third driving assembly for driving the traction rope reel 43 to rotate. The second installation assembly is provided with a limiting wheel assembly 46, which comprises a limiting wheel frame 464, and a first limiting wheel 461, a second limiting wheel 462 and a third limiting wheel 463 which are arranged in sequence in limiting the wheel frame 464. A first limiting opening for passing through the traction rope 211 is formed between the first limiting wheel 461 and the second limiting wheel 462, and a second limiting opening for passing through the cable 210 is formed between the second limiting wheel 462 and the third limiting wheel 463. The first limiting wheel 461 and the second limiting wheel 462 are integrated by a connecting rod 465, and an adjusting groove 466 is provided on the limiting wheel frame 464 for up and down movement of the connecting rod 465. The first limiting wheel 461 and the second lim-

iting wheel 462 in the limiting wheel assembly 46 allow position adjustment in vertical direction to prevent cable 210 from running off. A tension sensor is mounted on the first limit wheel 461.

[0054] The second installation assembly is similar to the first installation assembly and also comprises a second mounting plate 45 and a second spring plunger 44. A second guide rail groove 451 is provided in the second mounting plate 45 that matches the profile of the second guide rail 12. The third driving assembly comprises third motor 41. One end of the traction rope 211 is pulled through and wound around the traction rope reel 43, the traction rope reel 43 is installed in the traction rope reel frame 43, and driven by third motor 41 for winding; the other end of the traction rope 211 is connected to a cleaning robot. The second mounting plate 45 is installed under the traction rope reel frame and can be connected to the short guide rail. The second spring plunger 44 is used for quick installation and limiting.

(5) The auxiliary roller mechanism 5

[0055] The auxiliary roller mechanism 5 comprises a fixed frame 511, a moving frame 512 movable relative to the fixed frame 511, an adjusting assembly provided between the fixed frame 511 and the moving frame 512, limiting rollers provided in the moving frame 512 or the fixed frame 511, a lock-pin assembly 54 and a mounting rack assembly, limiting rollers 522 on moving frame 512 and limiting rollers 521 on fixed frame 511 are on both sides of high-pressure hose 29 respectively to limit the movement of high-pressure hose 29.

[0056] The adjusting assembly comprises an adjusting bolt and an elastic element in bolt hole 53 provided between the fixed frame 511 and the moving frame 512. The limiting rollers include fixed group limit rollers 521 in the fixed frame 511 and moving group limit rollers 522 in the moving frame 512. A connecting plate 57 is connected under the fixed and moving groups of rollers. The high-pressure hose 29 runs between the fixed and moving groups of rollers 521, 522. To facilitate installation, the clearance between the fixed group limit rollers 521 and the moving group limit rollers 522 can be adjusted by adjusting the adjusting bolt and the elastic element, so as to ensure that the high-pressure hose 29 contacts the rollers 212 disposed on both sides, and then it is locked by the lock-pin assembly 54 after the adjustment is completed. The mounting rack assembly comprises a mounting rack 55 and a third spring plunger 58 located on the mounting rack 55. A guide rail groove 56 matching the profile of the first guide rail is provided in the upper portion of the fixed frame 511, and the fixed frame 511 is socketed to the first guide rail 11 by the guide rail groove 56, as well as, the fixed frame 511 can be quickly mounted and fixed to the long guide rail by means of an axle-bore fit between the spring plunger located on the mounting rack 55 and the plunger hole.

[0057] Preferably, a circular flow tool can be installed

at the flange of handhole 8, the function of the circulation flow tool is to form a circular water flow along the inner wall of the steam generator, and to drive the sludge water flowing out from the area between the tubes after high-pressure water cleaning to the suction port, thus forming a closed water circulation loop. The circular flow tool can use the existing technology in application No. 201710303338.8. Additionally, some temporary blanking plates can be used to block the handhole temporarily during flushing to avoid introduction of foreign matters and to prevent water mist from escaping from inside of the steam generator.

[0058] The installation and operation of this cleaning device also requires a pulling trolley, which has the same rollers as those on the upper part of the cleaning mechanism, and has a high-pressure hose or a cable connector carried by means of a clamping mechanism. The coupling is transported from one handhole to the other by means of a pulling trolley, driven by a two-part, quick-threading connecting bar. After that, the pulling trolley and the connecting bar are taken out of the two handholes respectively, and the high-pressure hose connector or cable connector is connected to the cleaning mechanism, it can start drafting the cleaning mechanism to make it translate on the guide rail mechanism.

[0059] The installation process of the guide rail mechanism is as follows:

STEP 1: install the first guide rail in the handhole with larger outer space, and hang it on the divider plate by the first fixed block and the second fixed block; one end of the first guide rail can be used as an installation handle to facilitate installation;

STEP2: shorten the distance between the first slider and the first moving block by the tensioning guide rail and lock it, so that the first moving block is closely attached to the divider plate to realize the fixation of the first guide rail;

STEP3: install the second guide rail in the other handhole; hang the second moving block on the divider plate and insert the second guide rail into the first guide rail for connection, and then install the second clamping assembly so that the end of the second guide rail is continuously inserted in the end of the first guide rail to achieve fit and fixation between the guide rails;

[0060] The working process of the steam generator cleaning device in this embodiment is briefly described as follows:

STEP 1: install the guide rail mechanism on the divider plate, and secure it by the first clamping assembly and the second clamping assembly;

STEP2: connect the high-pressure hose to the clean-

ing mechanism by the pulling trolley, and install the cleaning mechanism at the starting position of the linear rail;

STEP3: connect the cable to a control system; connect the water inlet of the high-pressure hose reel mechanism to a water outlet of the pump;

STEP4: start the cleaning device by the control system; the high-pressure hose reel mechanism starts to rotate and pull the cleaning device until the proximity sensor senses the first positioning hole, and the high pressure pipe carousel mechanism stops the pulling action; the nozzle is activated according to a pre-programmed programme, and the nozzle starts to clean the area between the heat transfer tubes according to a set range and number of rotations;

STEPS: when the cleaning of an area between the tubes is finished, the high-pressure reel mechanism is started automatically to rotate until the proximity sensor senses the positioning hole again, then the pulling action is stopped and the cleaning action is started; the traction rope is kept under tension during the pulling process by means of the motor under the action of the tension sensor;

STEP6: repeat STEPS to complete the cleaning of all areas between the tubes, and then remove all parts of the cleaning device and take out the parts from the handholes.

[0061] In view of the problems of position change, poor translating accuracy, and inability to monitor in real time during the working process of the cleaning mechanism, which are caused by the rigid gun used in the steam generator cleaning device at home and abroad at present., this present invention is intended to improve the operation safety, positioning accuracy and to realize visualization with the following technical solution: a structure based on the flexible high-pressure hose and the pulling of the traction rope is designed to realize translating of the cleaning mechanism on the guide rails; the high-pressure hose and the traction rope are wound around their own reels respectively; the reels are installed on both ends of the cleaning guide rails; the precise translating of the cleaning mechanism is realized by the combination of the proximity sensor and the camera; a hole for proximity switch sensing and equal spacing with the heat transfer tubes is machined on the substrate of the guide rail, and through the sensing of the hole by the proximity switch, the proximity switch sends out a signal to control the rotation and stopping of the high-pressure water tube, thereby realising the translating of the cleaning mechanism 2 on the guide rail; real-time verification is carried out through the image of the second camera, and adjusted by rotating the high-pressure water pipe if

necessary; the use of the auxiliary roller system and the tension sensor prevents twisting of the high-pressure hose and the traction rope and allows positioning according to the required distance.

[0062] The steam generator cleaning device in this invention comprises the guide rail mechanism, the cleaning mechanism, the high-pressure hose reel mechanism, the traction rope reel mechanism and the auxiliary roller mechanism. The whole-section guide rail mechanism is installed under the divider plate of the steam generator, and a linear rail machined at the bottom of the guide rail for moving the cleaning mechanism. On the linear rail, positioning holes are machined at intervals matching the heat transfer tubes. The cleaning mechanism is installed on the linear rail, with a proximity switch installed at the center in it, and one end is connected to the traction rope reel and the other end is connected to the high-pressure hose mechanism, and the cleaning mechanism is pulled to move at equal steps under the whole-section type guide rail mechanism, by cooperative control of the traction rope reel and the high-pressure hose reel mechanism; the auxiliary roller mechanism is provided to limit the moving route of the high-pressure hose, and ensure the reliable movement of the reel; to control the movement of the high-pressure hose reel mechanism by means of the proximity switch sensing the positioning holes in the linear rail, and under the cooperative control of the traction rope reel mechanism, it is possible to guarantee the stable state of the cleaning mechanism on the guideway, ensure the stability of the cleaning mechanism on the guide rails, improve the positioning accuracy of the cleaning mechanism, drive the nozzle for precise movement and visualized monitoring, ensure good cleaning effect, reduce changing frequency of the rigid gun during cleaning, increase cleaning efficiency and reduce the exposure dose of field operators.

[0063] The above embodiment is intended to explain the technical concepts and features of this invention, and to help the personnel familiar with this technology to understand the contents of this invention and embody it accordingly, and not to limit the protected scope of this invention. Any equivalent changes or modifications based on the essence of this invention shall be included in the protected scope of this invention.

Claims

1. A guide rail mechanism suitable for cleaning a steam generator, comprising a first guide rail and a second guide rail which are fitted to each other by inserting, and a linear rail provided on both the first guide rail and the second guide rail; several positioning holes are provided in the linear rail; the distance between adjacent positioning holes is the same as the distance between adjacent heat transfer tubes in the steam generator; the positioning holes is used to cooperate with the positioning holes for translating po-

sitioning of the cleaning mechanism; the guide rail mechanism comprises a first clamping assembly and a second clamping assembly on first guide rail and second guide rail respectively for clamping the left and right parts of the divider plate in the steam generator.

2. The guide rail mechanism according to Claim 1, wherein the first clamping assembly comprises a first fixed block, a first moving block, and a first clamping assembly for driving the first moving block close to the first fixed block; the second clamping assembly comprises a second fixed block, a second moving block, and a second clamping assembly for driving the first guide rail and the second guide rail to insert them into each other.
3. The guide rail mechanism according to Claim 2, wherein the first fixed block, the first moving block, the first clamping assembly and the second fixed block are located on one of the first guide rail and the second guide rail, and the second moving block and the second clamping assembly are located on the other one of the first guide rail and the second guide rail.
4. The guide rail mechanism according to Claim 2, wherein the first clamping assembly comprises a first slider, a tensioning guide rail and a first lead screw; one end of the first lead screw is connected to the first fixed block by a rotary joint, and the other end of the first lead screw runs through the first slider;

a clamping section is provided on the lower part of the first slider, and a first sliding groove is provided at each side of the first guide rail, the clamping section is accommodated within the first sliding groove;

a clipping groove is provided in the tensioning guide rail, and the upper portion of the first slider is snapped into the clipping groove; the movement of the tensioning guide is achieved by moving the first slider in the clipping groove.

5. The guide rail mechanism according to Claim 4, wherein a traction frame is provided at one end of the tensioning guide rail close to the first slider, and the traction frame is socketed to the first moving block; a second sliding groove corresponding to the first moving block is provided in the first guide rail, and a second clamping section corresponding to the second sliding groove is provided on the lower portion of the first moving block, the second clamping section is accommodated in the second sliding groove
6. The guide rail mechanism according to Claim 5,

wherein a hook plate extending downwardly is provided at one end of the traction frame away from the tensioning guide rail; the hook plate is used to affix to and hook the first moving block.

7. The guide rail mechanism according to Claim 5, wherein a positioning block is provided on the tensioning guide rail; the positioning block is located at one end of the clipping groove away from the traction frame, and the positioning block is used to limit the movement of the first slider.
8. The guide rail mechanism according to Claim 2, wherein the second clamping assembly comprises fasteners, a second slider, a second lead screw and an installation block; one end of the second lead screw is connected to the installation block by a rotary joint, and the other end of the second lead screw runs through the second slider;

a limiting part is provided in the lower portion of the second slider, and a limiting groove is provided in each side of the second guide rail, the limiting part is accommodated in the limiting groove;

the fasteners and the installation block are used to fix the second clamping assembly on the flange of the handhole of the steam generator.

9. The guide rail mechanism according to Claim 8, wherein the second clamping assembly comprises a mounting flange; the mounting flange is used to match with the handhole flange of the steam generator to realize the installation of the guide rail mechanism.
10. The guide rail mechanism according to Claim 4, wherein a camera is provided at one end of the tensioning guide rail close to the traction frame, and the camera is used for visually aided installation; a wireway is provided in the tensioning guide rail for accommodating a cable of the camera.
11. The guide rail mechanism according to Claim 6, wherein an inserter is provided at one end of the second guide rail, and a socket is provided at one end of the first guide rail; the inserter is accommodated within the socket to realize the connection between the first guide rail and the second guide rail.
12. An installation method for the guide rail mechanism according to any of Claims 1-11, which includes the following steps:

a) Put the first guide rail into the steam generator through a handhole, and hang it on a divider plate of the steam generator by the first fixed block and the second fixed block;

- b) Shorten the distance between the first slider and the first moving block by the tensioning guide rail and lock it, so that the first moving block is closely attached to the divider plate to realize the fixation of the first guide rail;
- c) Put the second guide rail into the steam generator through the other handhole; hang the second moving block on the divider plate, and insert the second guide rail into the first guide rail for connection;
- d) Install the second clamping assembly so that one end of the second guide rail is continuously inserted in one end of the first guide rail to achieve the connection between the first guide rail and the second guide rail and the fixation between the guide rail mechanism and the divider plate.
13. A steam generator cleaning device, comprising a guide rail mechanism according to any of Claims 1-10, a cleaning mechanism, a traction mechanism, a high-pressure hose reel mechanism and a traction rope reel mechanism;
- a proximity sensor is provided in the cleaning mechanism to cooperate with the positioning holes for translating positioning of the cleaning mechanism ;
- the traction mechanism comprises a high-pressure hose and a traction rope are provided on both sides of the cleaning mechanism respectively; the high-pressure hose is used to supply water to the cleaning mechanism; the high-pressure hose reel mechanism is used to wind the high-pressure hose to move the cleaning mechanism.
14. The cleaning device according to Claim 13, wherein the cleaning mechanism comprises an auxiliary roller mechanism for the support of the high-pressure hose; the auxiliary roller mechanism comprises a fixed frame, a moving frame moving relatively to the fixed frame, an adjusting assembly provided between the fixed frame and the moving frame, and limiting rollers provided on the moving frame or the fixed frame; the limiting rollers on the moving frame and the fixed frame are on each side of the high-pressure hose respectively to limit the movement of the high-pressure hose.
15. The cleaning device according to Claim 14, wherein the adjusting assembly comprises an adjusting bolt and an elastic element between the fixed frame and the moving frame; the limiting rollers include fixed group limit rollers in the fixed frame and moving group limit rollers in the moving frame; the high-pressure hose runs between the fixed group limit rollers and the moving group limit rollers .
16. The cleaning device according to Claim 14, wherein the auxiliary roller mechanism comprises a lock-pin assembly and a mounting rack assembly; the mounting rack assembly comprises a mounting rack and a spring plunger located on the mounting rack; a guide rail groove matching the profile of the first guide rail is provided in the upper portion of the fixed frame, and the fixed frame is socketed to the first guide rail by the guide rail groove, and the fixed frame is quickly mounted and fixed to the long guide rail by means of an axel-bore fit between the spring plunger located on the mounting rack and the plunger hole.
17. The cleaning device according to Claim 13, wherein the cleaning mechanism comprises a frame, a nozzle carrier, a cable holder and rollers, and a first driving assembly for driving the nozzle carrier to rotate; the nozzle carrier, the cable holder and the plurality of rollers are provided on the frame; the proximity switch is provided on the top of the frame and cooperates with the positioning holes in the linear rail; the plurality of rollers are provided on both sides of the linear rail to allow the cleaning mechanism to move along the linear rail.
18. The cleaning device according to Claim 17, wherein the high-pressure hose reel mechanism comprises a high-pressure hose reel, a first reel frame, a hose connector outlet, a rotary joint, a first installation assembly, and a second driving assembly for driving the high-pressure hose reel to rotate; a through hole is provided in the high-pressure hose reel; one end of the high-pressure hose is connected to the nozzle carrier, and the other end of the high-pressure hose is connected to the rotary joint after passing through the through hole and the hose connector outlet; the first installation assembly is used to secure the high-pressure hose reel mechanism on the first guide rail.
19. The cleaning device according to Claim 18, wherein the first installation assembly comprises a first mounting plate, a first spring plunger and a transition wheel assembly;
- a first guide rail groove matching the profile of the first guide rail is provided in the first mounting plate 35; the first mounting plate is located under the reel frame and connected to the first guide rail long through a first spring plunger provided on the first mounting plate;
- the second driving assembly comprises a second motor and a coupling; the second motor drives the high-pressure hose reel to retract and release the high-pressure hose; and the second motor is connected to the spool of the reel through the elastic coupling.

20. The cleaning device according to Claim 16, wherein the traction rope reel mechanism comprises a traction rope reel, a second reel frame, a second installation assembly, and a third driving assembly for driving the traction rope reel to rotate; 5
- a limiting wheel assembly is provided in the second installation assembly, which comprises a limiting wheel frame, and a first limiting wheel, a second limiting wheel and a third limiting wheel which are arranged in sequence in the limiting wheel frame; 10
- a first limiting opening for passing through the traction rope is formed between the first limiting wheel and the second limiting wheel, and a second limiting opening for passing through the cable connected to the cleaning mechanism is formed between the second limiting wheel and the third limiting wheel. 15
21. The cleaning device according to Claim 20, wherein the second installation assembly comprises a second mounting plate and a second spring plunger; a second track groove matching the shape of the second guide rail is provided in the second mounting plate. 20
22. The cleaning device according to Claim 14, wherein an inserter is provided at one end of the second guide rail, and a socket is provided at one end of the first guide rail; the inserter is accommodated within the socket to realize the connection between the first guide rail and the second guide rail; 30
- the high-pressure hose reel mechanism is provided on the end of the first guide rail away from the socket; 35
- the auxiliary roller mechanism is provided between the high-pressure hose reel mechanism and the socket; the traction rope reel mechanism is provided on the end of second guide rail away from the inserter; the second clamping assembly is provided between the traction rope reel mechanism and the inserter. 40
23. A cleaning method for cleaning steam generators using the cleaning device according to any of Claims 13-22, which includes the following steps: 45
- 1) Install the guide rail mechanism on the divider plate of the steam generator by the first clamping assembly and the second clamping assembly; 50
- 2) Connect the high-pressure hose to the cleaning mechanism, and move the cleaning mechanism to the starting position of the linear rail;
- 3) Connect the cable of the cleaning mechanism to the control system; connect the water inlet of the high-pressure hose reel mechanism to the water outlet of the pump; 55
- 4) Start the cleaning device by a control system;

the high-pressure hose reel mechanism starts to rotate and pull the cleaning device to move until the proximity sensor senses the first positioning hole, and the high pressure pipe carousel mechanism stops the pulling action; then start the nozzle on the cleaning mechanism and start to clean the area between the heat transfer tubes;

5) When the cleaning of the area between tubes is finished, restart the high-pressure hose reel mechanism to rotate until the proximity sensor senses the positioning hole again; restart the nozzle on the cleaning mechanism and start to clean the area between the heat transfer tubes;

6) Repeat Step 5) to complete the cleaning of all areas between tubes, then remove all parts of the cleaning device and take out the parts from the handholes, and the cleaning is completed.

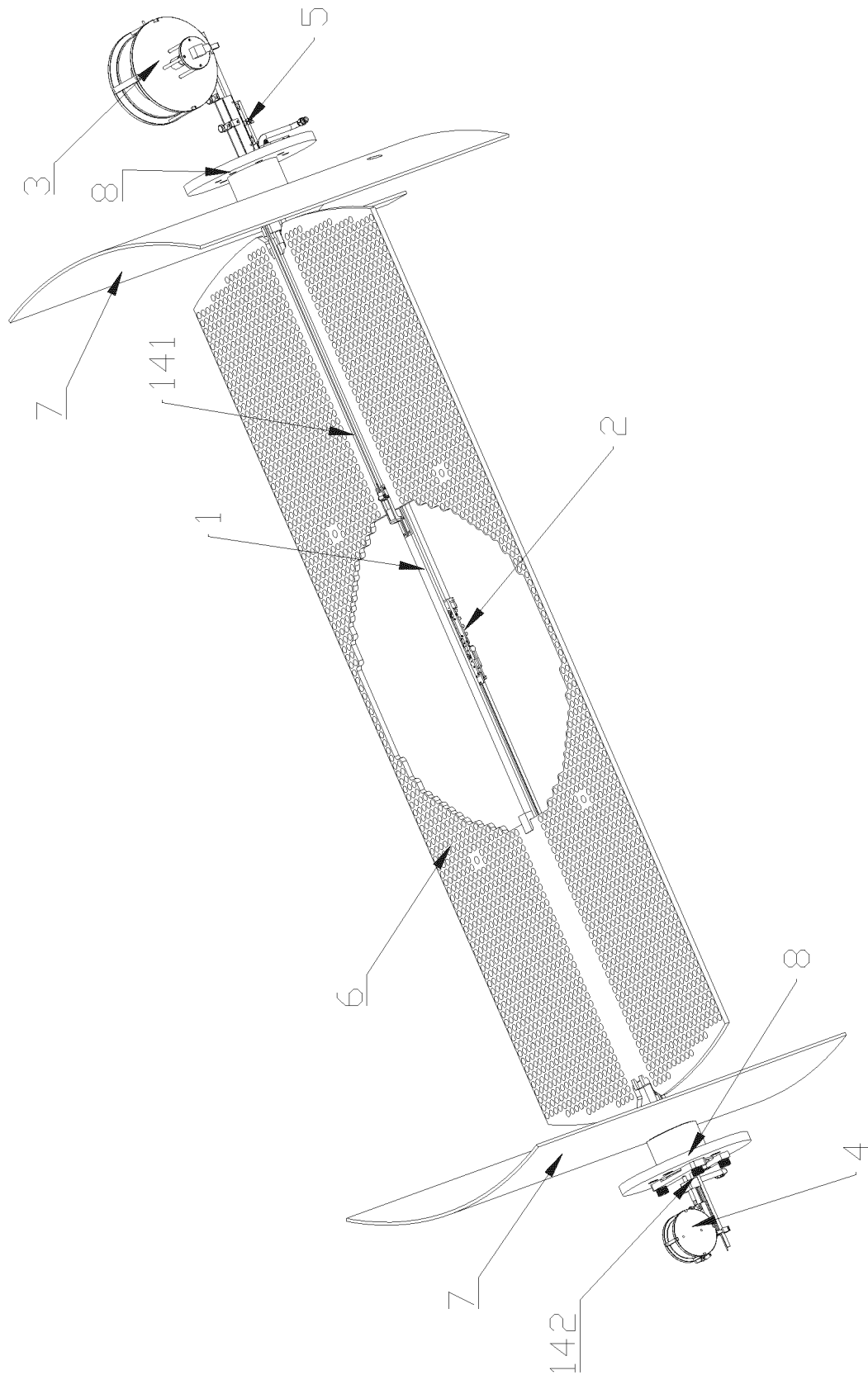


Figure 1

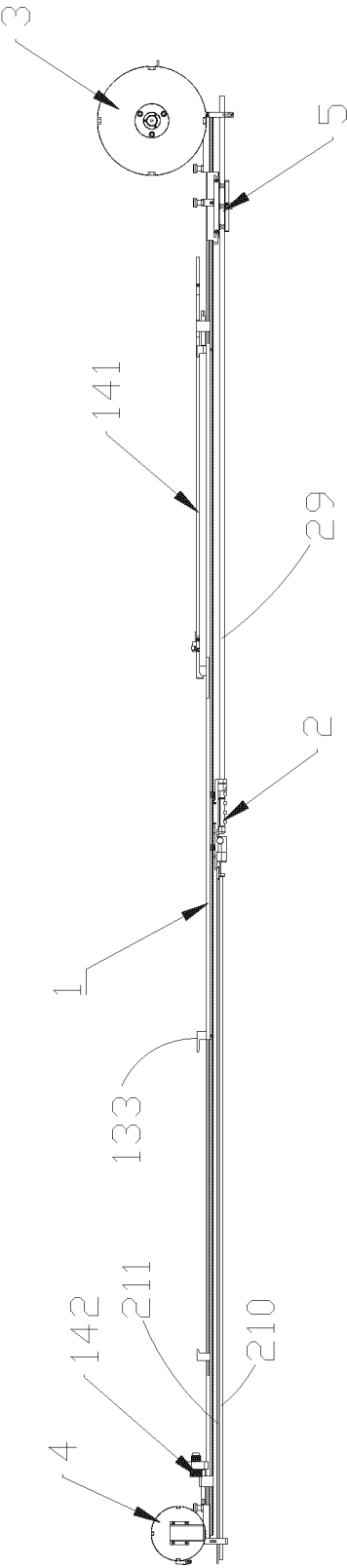


Figure 2

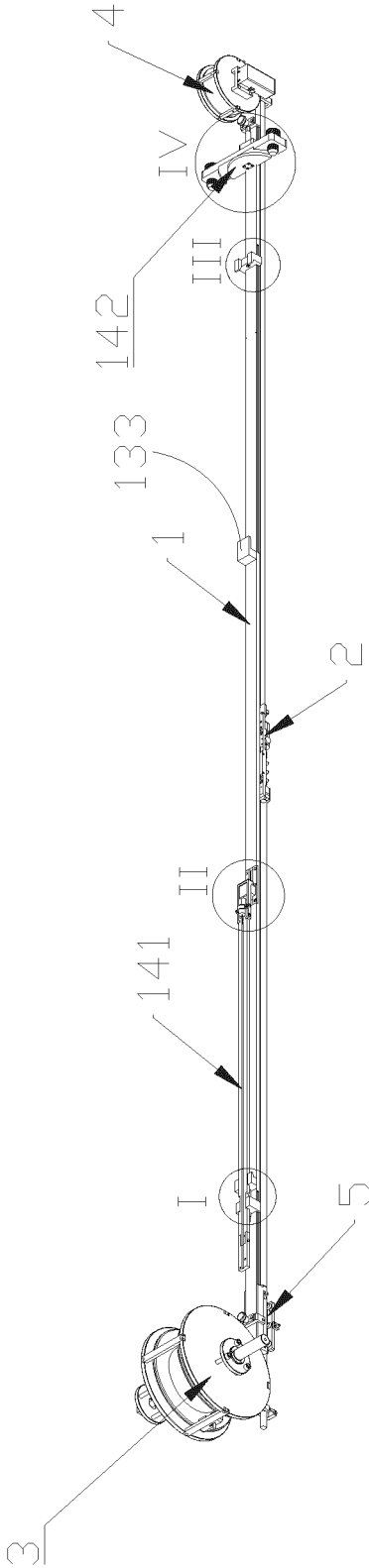


Figure 3

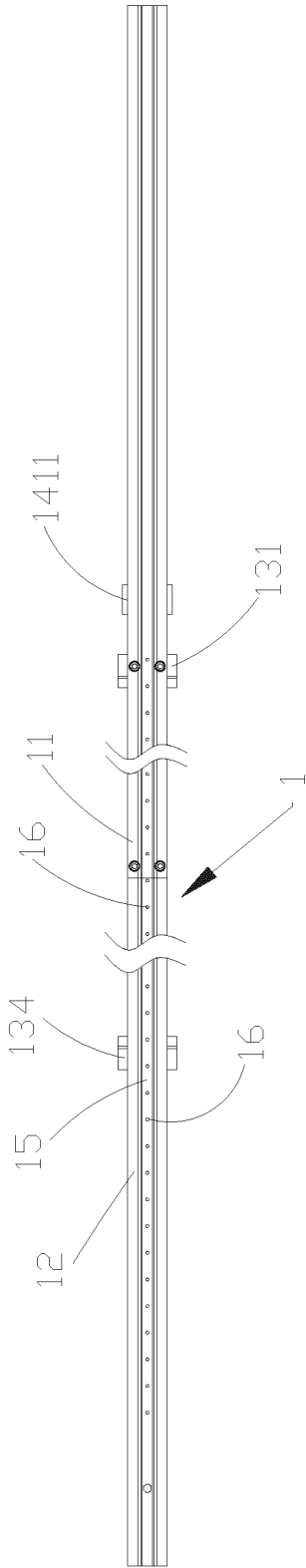


Figure 4

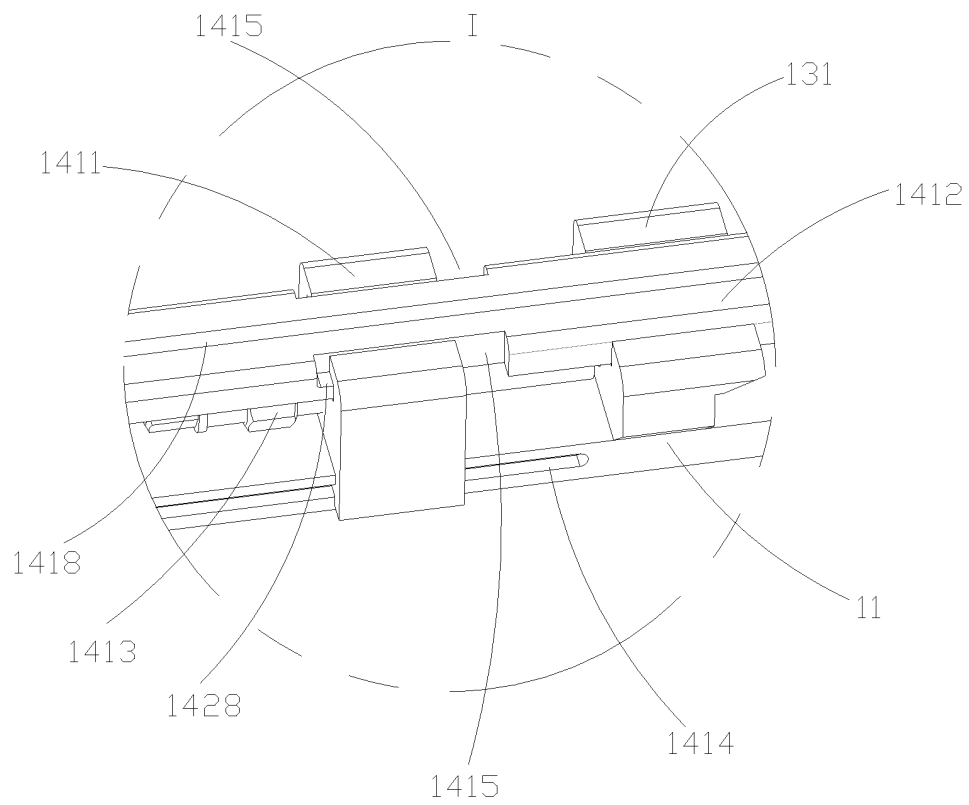


Figure 5

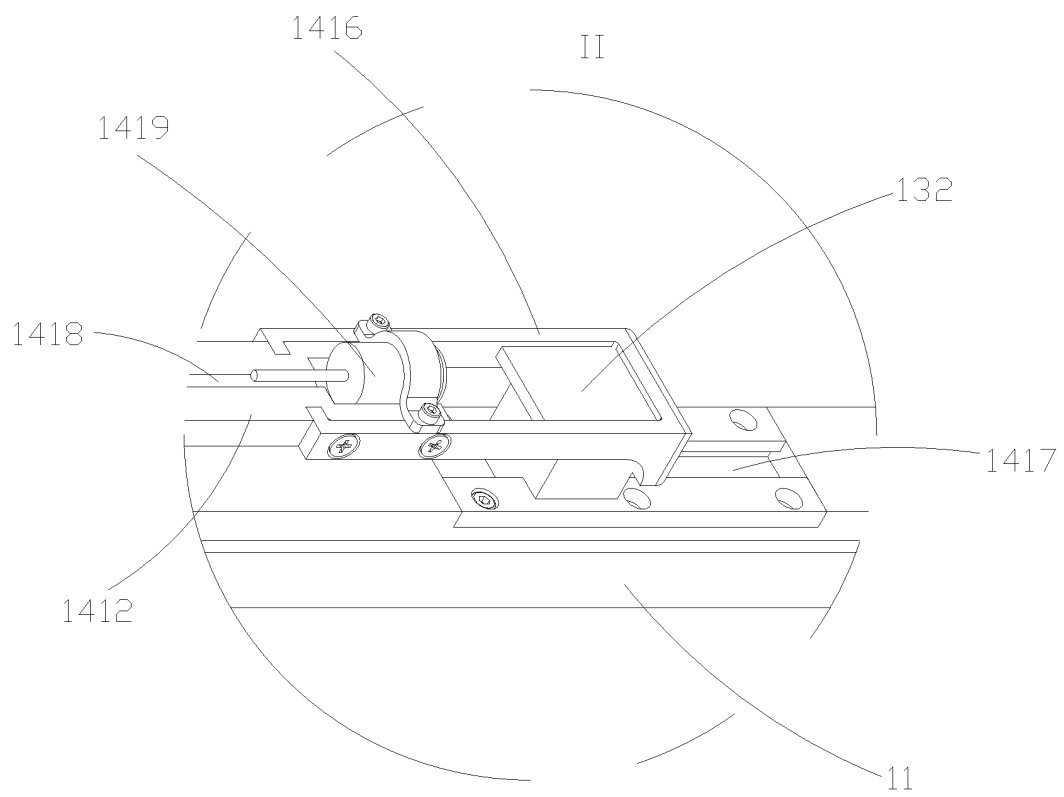


Figure 6

III

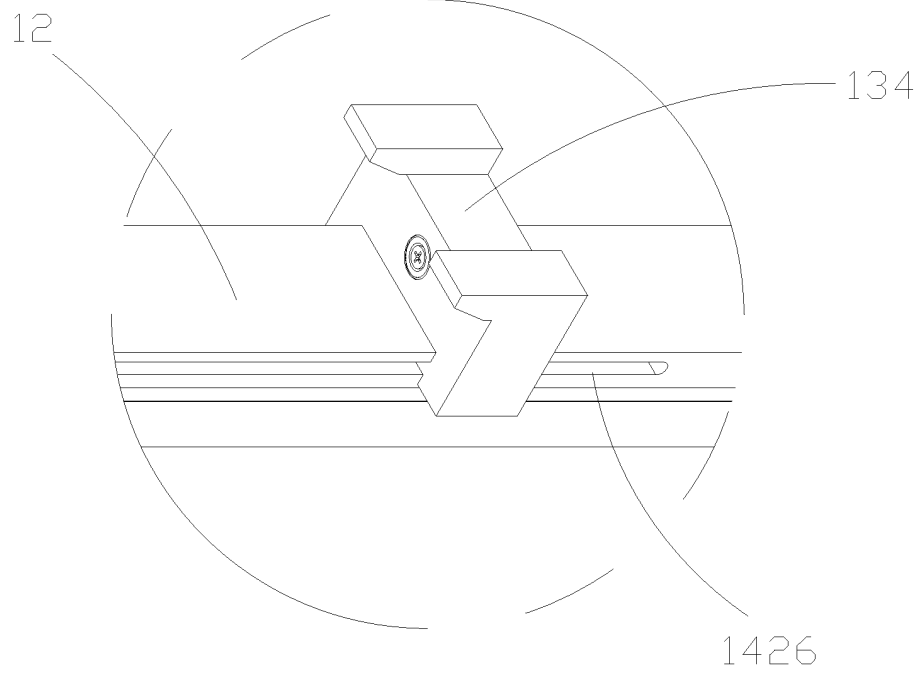


Figure 7

IV

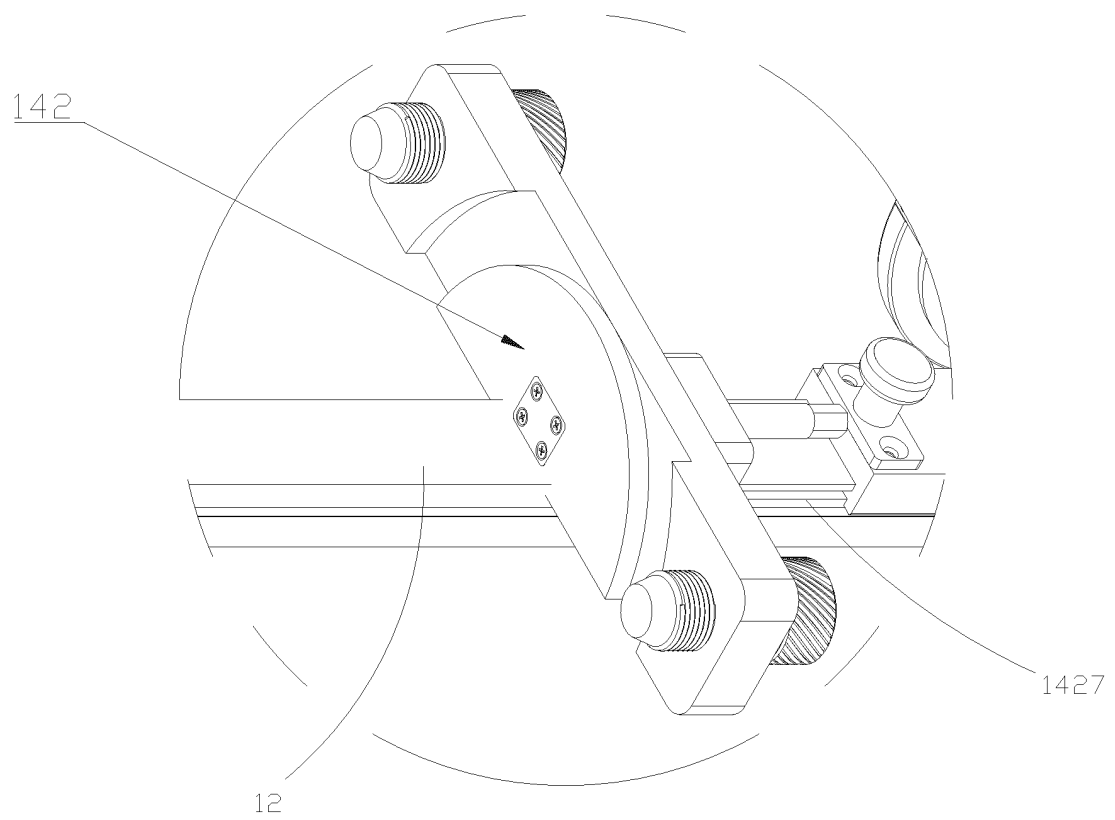


Figure 8

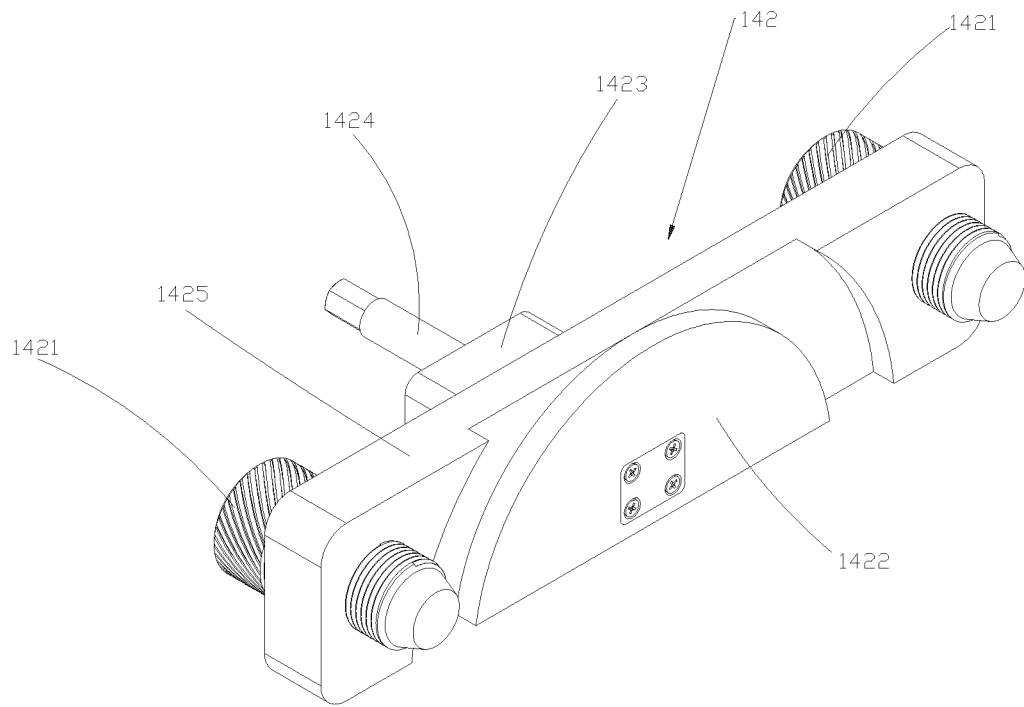


Figure 9

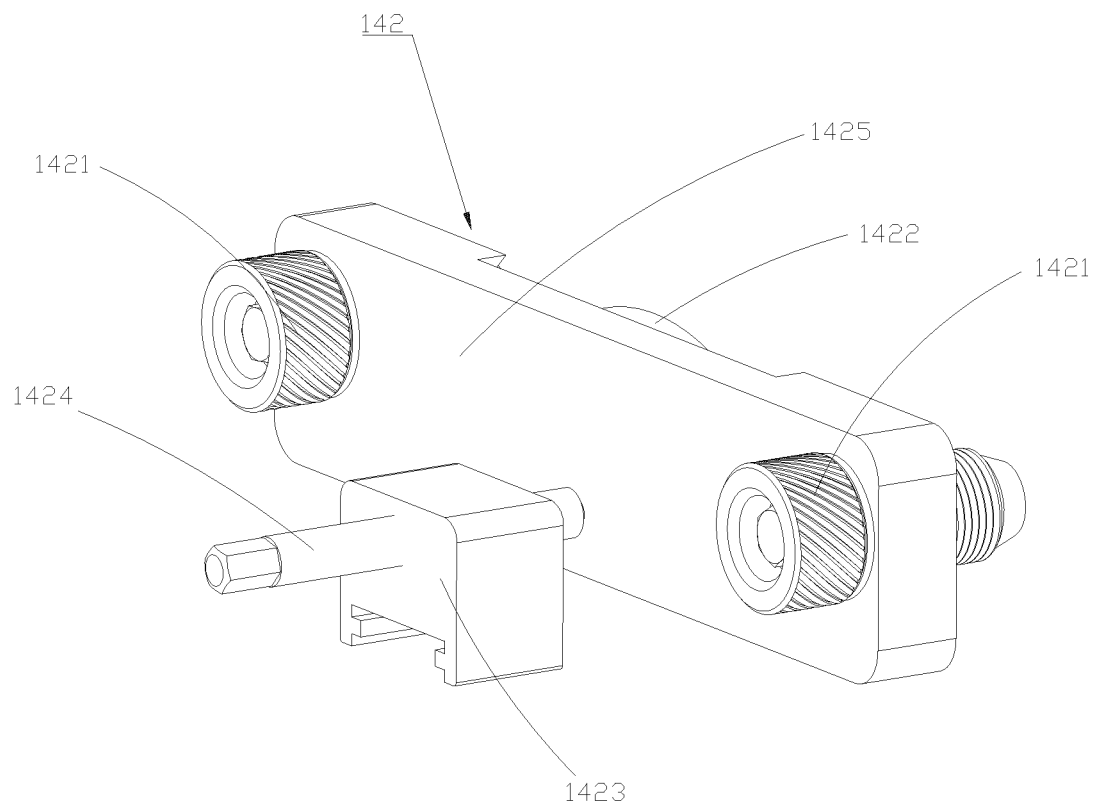


Figure 10

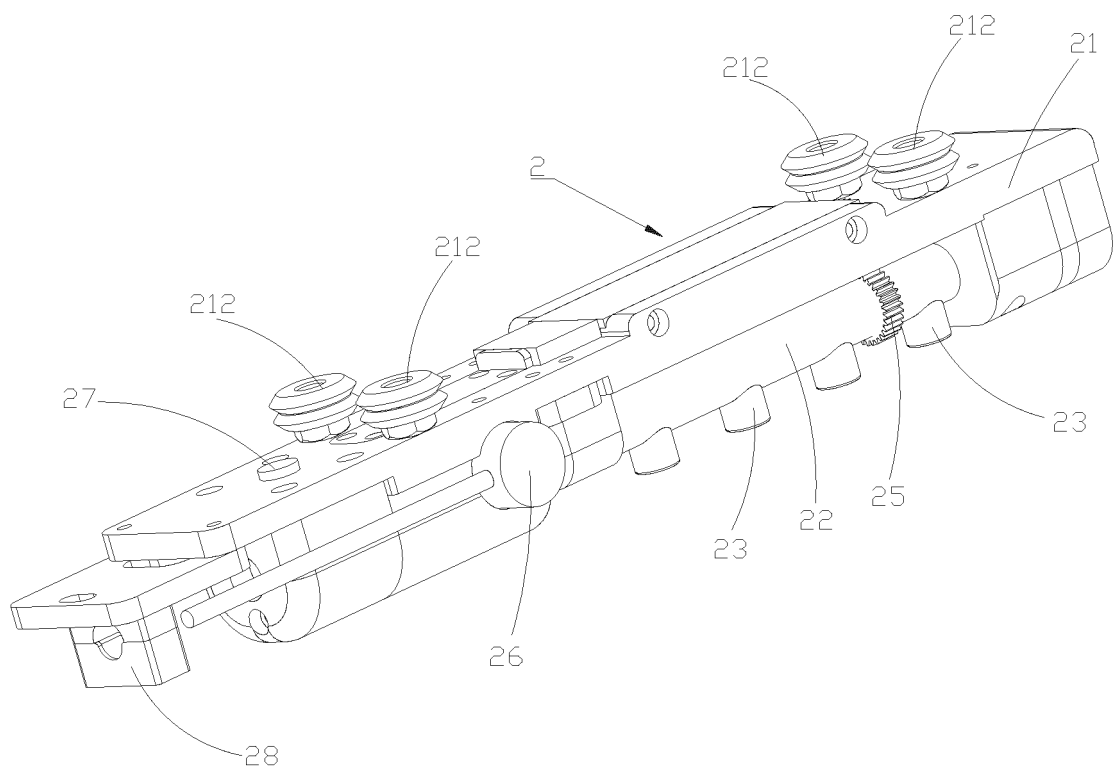


Figure 11

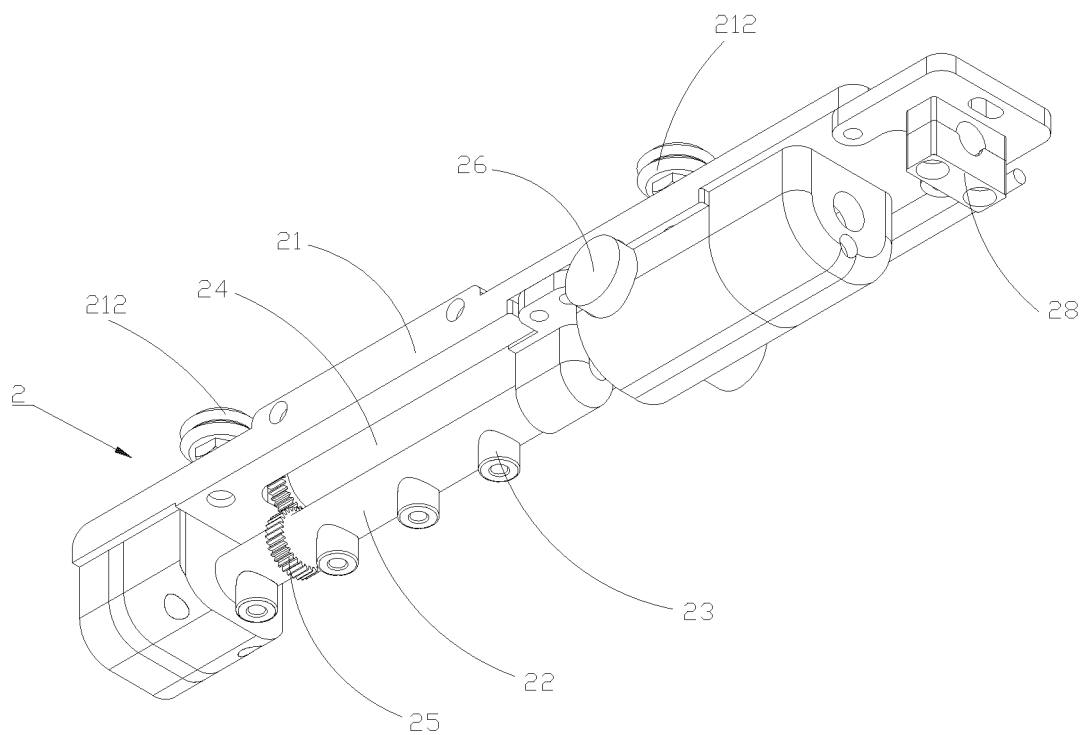


Figure 12

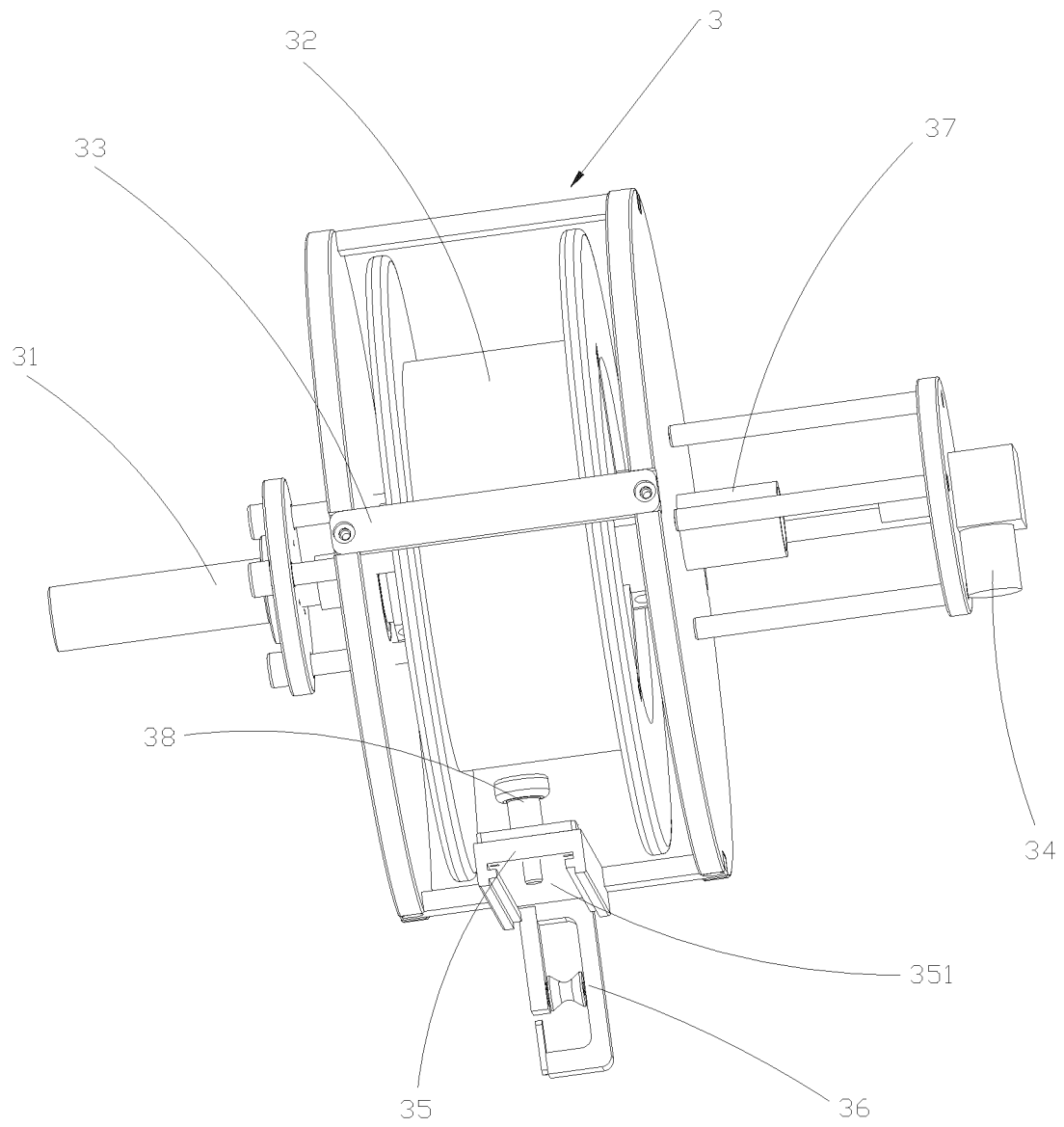


Figure 13

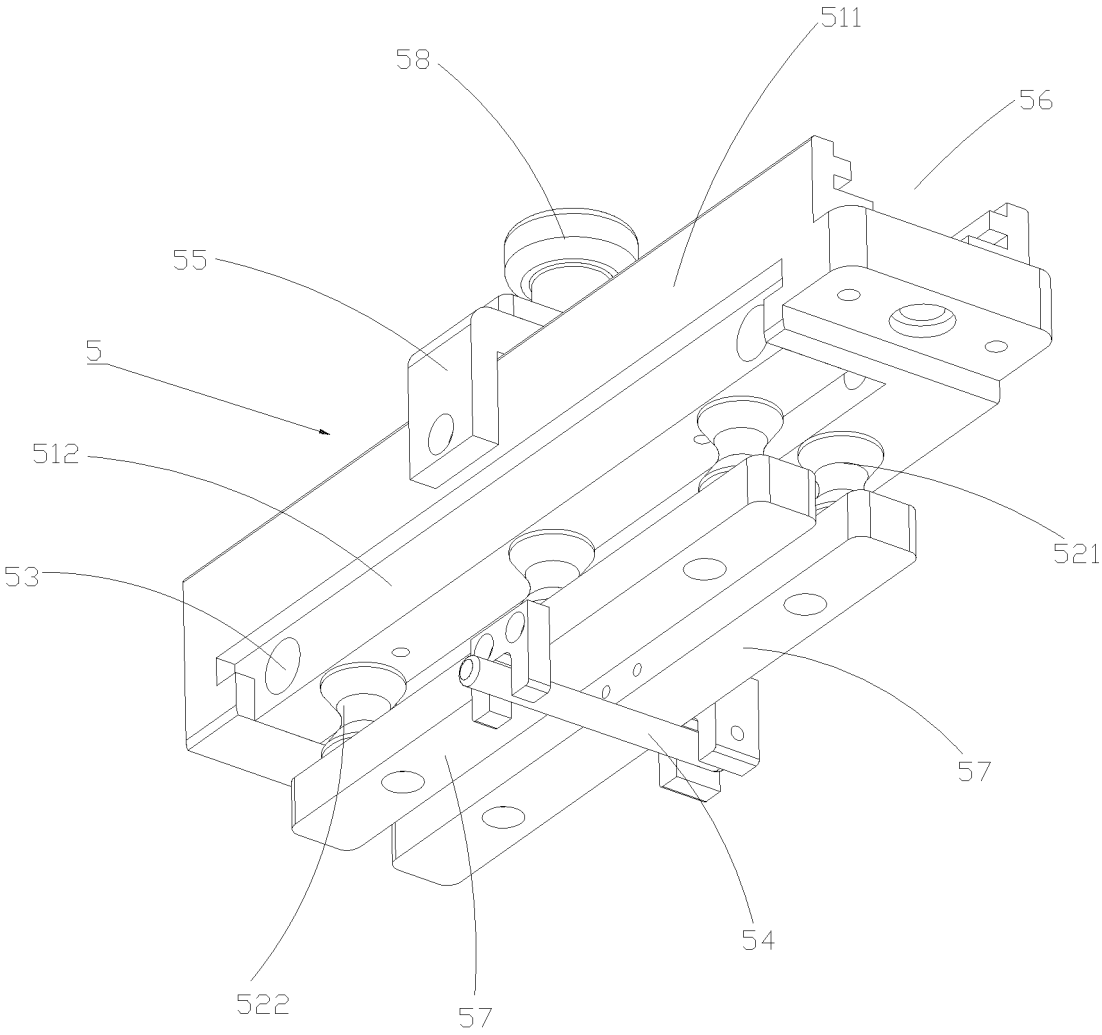


Figure 14

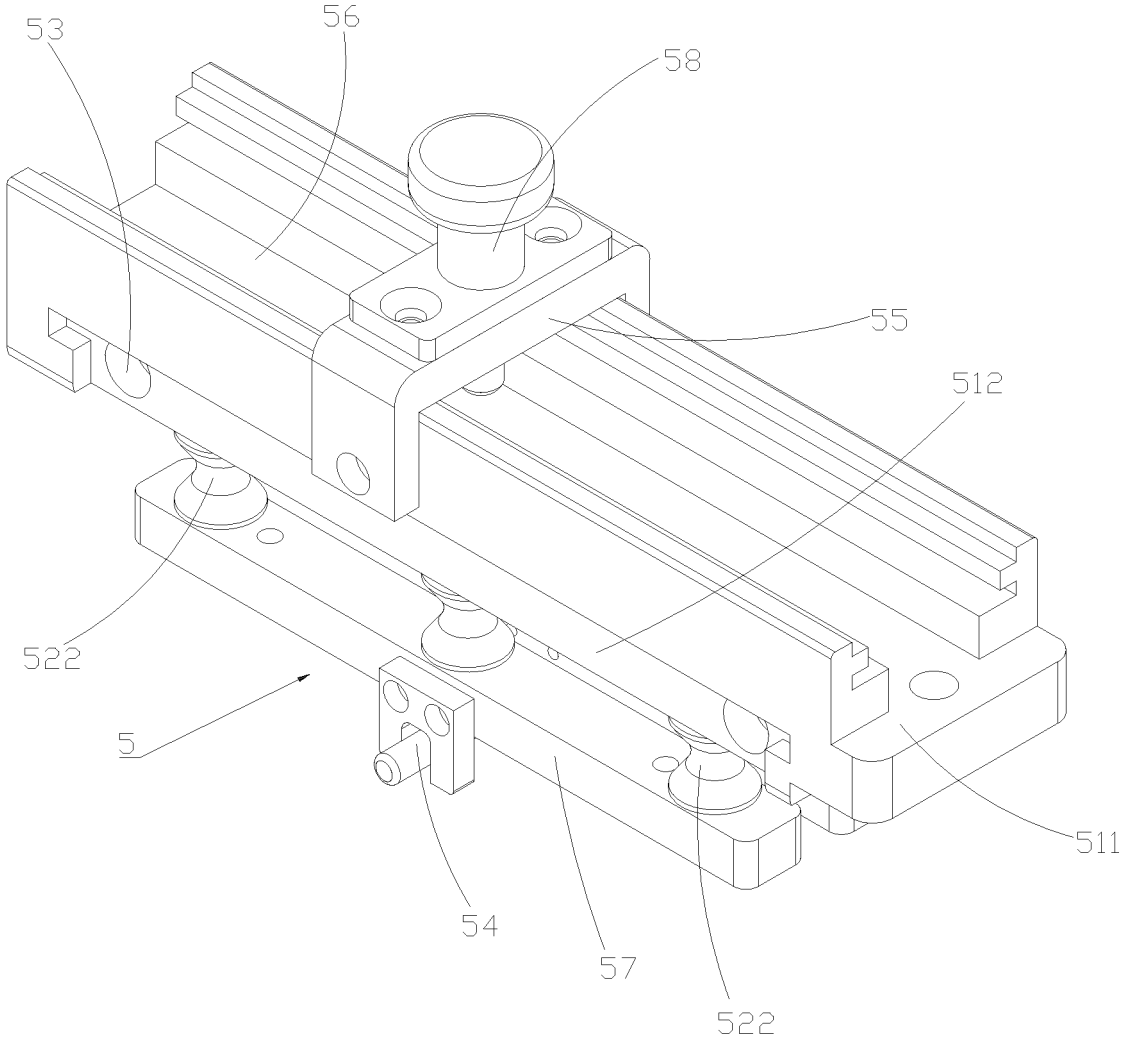


Figure 15

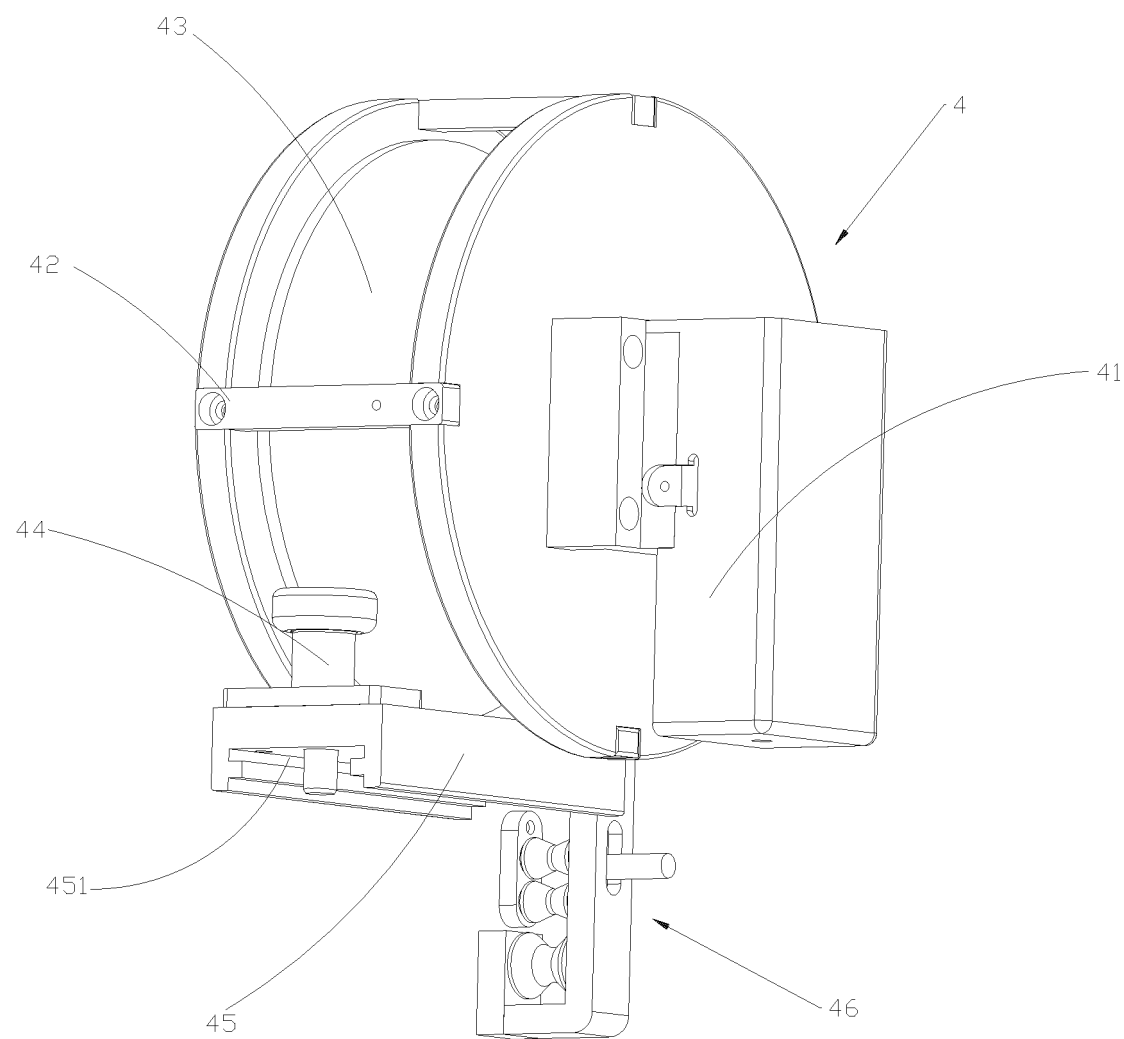


Figure 16

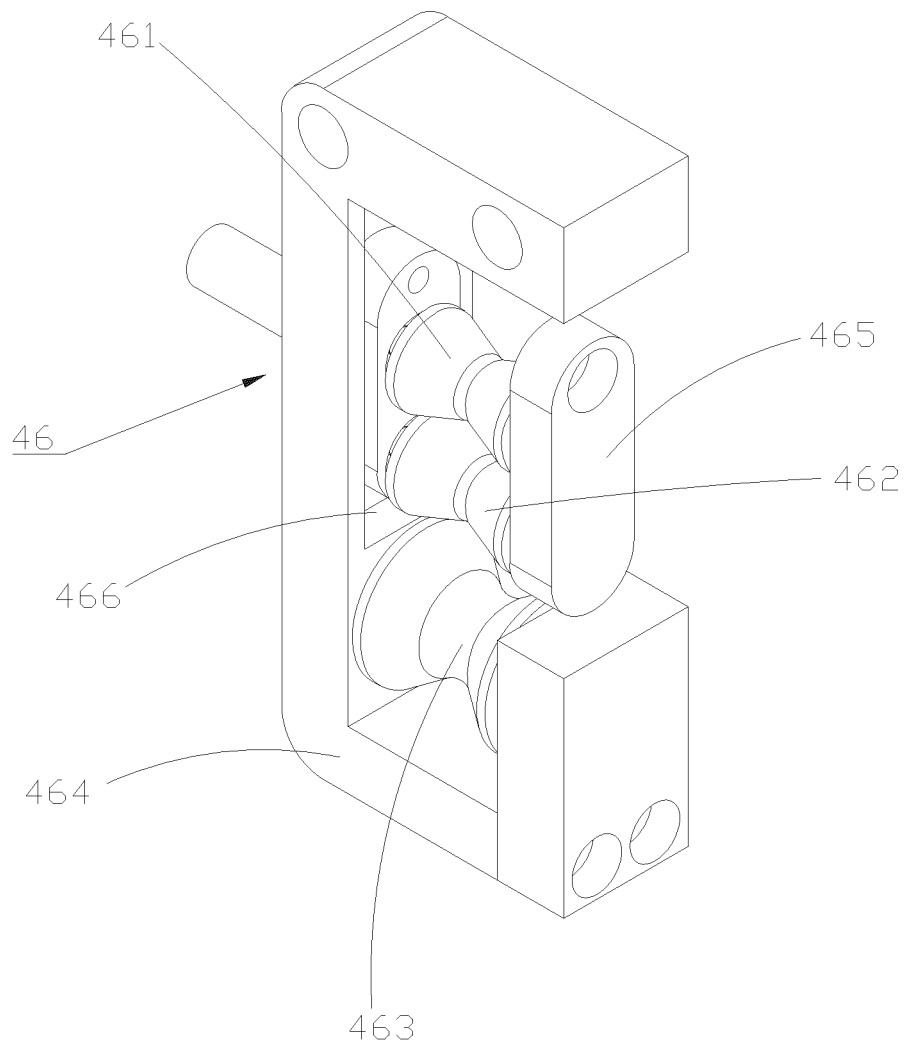


Figure 17

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2022/104046

A. CLASSIFICATION OF SUBJECT MATTER

F28G 15/02(2006.01)i; F22B 37/52(2006.01)i

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)

F28G; F22B

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, CNABS, VEN, CNTXT, CNKI: 蒸汽发生器, 导轨, 第一, 第二, 全段, 定位孔, 分流板, 夹持, guide 2d rail?, position + 2d hole?, clamping, splitter plate, steam generator

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 114234168 A (SUZHOU NUCLEAR POWER RESEARCH INSTITUTE et al.) 25 March 2022 (2022-03-25) claims 1-11, and description, paragraphs [0050]-[0090]	1-23
PX	CN 114321876 A (SUZHOU NUCLEAR POWER RESEARCH INSTITUTE et al.) 12 April 2022 (2022-04-12) claims 1-11	13-23
Y	CN 107152886 A (SUZHOU NUCLEAR POWER RESEARCH INSTITUTE et al.) 12 September 2017 (2017-09-12) description, paragraphs [0003]-[0058], and figures 1-11	1
A	CN 107152886 A (SUZHOU NUCLEAR POWER RESEARCH INSTITUTE et al.) 12 September 2017 (2017-09-12) entire document	2-23
Y	CN 109058235 A (GUANGDONG WOTAI ENVIRONMENTAL PROTECTION TECHNOLOGY CO., LTD.) 21 December 2018 (2018-12-21) description, paragraphs [0003]-[0130], and figures 1-12	1

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

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"E" earlier application or patent but published on or after the international filing date	"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
"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)	"&" document member of the same patent family
"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	

Date of the actual completion of the international search

20 September 2022

Date of mailing of the international search report

10 October 2022

Name and mailing address of the ISA/CN

China National Intellectual Property Administration (ISA/
CN)
No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing
100088, China

Authorized officer

Facsimile No. (86-10)62019451

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2022/104046

5

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 109058235 A (GUANGDONG WOTAI ENVIRONMENTAL PROTECTION TECHNOLOGY CO., LTD.) 21 December 2018 (2018-12-21) entire document	2-23
A	CN 111735040 A (RESEARCH INSTITUTE OF NUCLEAR POWER OPERATION et al.) 02 October 2020 (2020-10-02) entire document	1-23
A	FR 2761763 A1 (FRAMATOME SA) 09 October 1998 (1998-10-09) entire document	1-23

10

15

20

25

30

35

40

45

50

55

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/CN2022/104046

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	114234168	A	25 March 2022	None			
CN	114321876	A	12 April 2022	None			
CN	107152886	A	12 September 2017	None			
CN	109058235	A	21 December 2018	None			
CN	111735040	A	02 October 2020	None			
FR	2761763	A1	09 October 1998	BE	1011657	A3	09 November 1999
				ZA	9802959	B	09 October 1998
				ZA	982959	B	09 October 1998

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO 201710303338 A [0004] [0057]