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(54) 3D PRINTING CONSTRUCTION APPARATUS AND CONSTRUCTION METHOD

(57) The present disclosure relates to the technical field of 3D printing, in particular to a 3D printing construction apparatus and a construction method. The 3D printing construction apparatus includes: an operation structure, including a control room, a controller being arranged in the control room; a printing arm structure, arranged on one side of the control room and including a printing arm and a feed delivery pipe, the feed delivery pipe being suitable for flowing of concrete or slurry; and a printing arm head structure, arranged at one end of the printing arm structure away from the control room and including an arm head and a first rotating power part, wherein the first rotating power part is in communication connection with the controller, a grouting nozzle and a concrete printing nozzle are arranged at two opposite ends of the arm head, diameters of the grouting nozzle and the concrete printing nozzle are different, and the first rotating power part drives the arm head to rotate, so as to drive the grouting nozzle or the concrete printing nozzle to be in pipeline connection with the feed delivery pipe. In the present disclosure, a problem that a 3D printing device cannot print concrete with different performances and flows is solved.

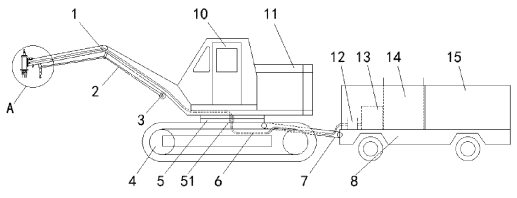


Fig.1

EP 4 427 895 A1

Description

TECHNICAL FIELD

[0001] The disclosure relates to the technical field of 3D printing, in particular to a 3D printing construction apparatus and a construction method.

BACKGROUND

[0002] A 3D printing technology is in a rapid development stage, and various 3D printing devices are emerging in an endless stream. 3D printing is rapidly promoted and used in all industries of production and manufacturing with its fast and efficient characteristics and an ability to easily manufacture some complex structures. 3D printing has the advantage of convenient molding, and an accuracy of a three-dimensional structure is guaranteed. In the construction industry, the 3D printing technology is also used for model casting and overall manufacturing.

[0003] In an existing 3D printing device, performances and flow rates of concrete flowing out during printing are the same, resulting in inability to print complex structures and buildings formed by combining different concrete performances, thereby affecting the scope and effect of application.

SUMMARY

[0004] Therefore, the technical problem to be solved by the present disclosure is to overcome the defect that performances and flow rates of concrete flowing out of a 3D printing device in the prior art are the same, which cannot print complex structures and buildings formed by combining different concrete performances, so that a 3D printing construction apparatus and a construction method are provided.

[0005] In order to solve the above problem, the present disclosure provides a 3D printing construction apparatus, including:

an operation structure, including a control room, a controller being arranged in the control room;

a printing arm structure, arranged on one side of the control room, the printing arm structure including a printing arm and a feed delivery pipe, and the feed delivery pipe being suitable for flowing of concrete or slurry; and

a printing arm head structure, arranged at one end of the printing arm structure away from the control room, the printing arm head structure including an arm head and a first rotating power part, wherein the first rotating power part is in communication connection with the controller, a grouting nozzle and a concrete printing nozzle are arranged at two opposite ends of the arm head, diameters of the grouting nozzle and the concrete printing nozzle are different, and the first rotating power part drives the arm head to rotate, so as to drive the grouting nozzle or the concrete printing nozzle to be in pipeline connection with the feed delivery pipe.

[0006] Optionally, a proximity switch is arranged on the arm head, the proximity switch is in communication connection with the controller, and the proximity switch is configured to determine a rotation position of the arm head.

[0007] Optionally, the first rotating power part is fixedly provided with a rotating end, the arm head is provided with a force bearing end, a transmission belt is arranged between the rotating end and the force bearing end, and the rotating end rotates to drive the arm head to rotate.

[0008] Optionally, the printing arm includes at least two rotating joints, a second rotating power part is arranged between the rotating joints, and the second rotating power part is in communication connection with the controller.

[0009] Optionally, the 3D printing construction apparatus further includes a trailer, the trailer is arranged at one end of the control room facing away from the printing arm, the trailer is provided with a trailer body, a delivery pump, a concrete tank, a mortar tank, a sequencing valve, an admixture tank, a water tank, a hydraulic control valve and a liquid delivery pump are arranged in the trailer body, the delivery pump is in pipeline connection with the feed delivery pipe, the delivery pump, the sequencing valve, the hydraulic control valve and the liquid delivery pump are in signal connection with the controller respectively, the concrete tank is in pipeline connection with the sequencing valve through a concrete pipe, the mortar tank is in pipeline connection with the sequencing valve through a grouting pipe, the sequencing valve is in pipeline connection with the delivery pump, an output end of the delivery pump is connected with the feed delivery pipe, the admixture tank and the water tank are connected with the hydraulic control valve respectively through pipelines, the hydraulic control valve is in pipeline connection with the liquid delivery pump, and the liquid delivery pump is connected with a nozzle through a liquid delivery pipe.

[0010] Optionally, a walking structure is arranged below the control room, and the control room is rotatably connected with the walking structure.

[0011] Optionally, the 3D printing construction apparatus further includes a stirring pipe arranged close to the arm head and connected with the feed delivery pipe, wherein a driving structure, a stirring paddle and a stirring shaft are arranged in the stirring pipe, two ends of the stirring shaft are connected with the stirring pipe through supporting of support frames, the driving structure drives the stirring shaft to stir, one end of the stirring pipe facing away from the arm head is connected with a liquid delivery pipe, the liquid delivery pipe is suitable for flowing of water or an additive, the stirring pipe is fixed to the printing arm structure through a fixing pier, a feeding pipe is arranged in an arm head cavity of the arm head, the feed delivery pipe is arranged between the feeding pipe and

the stirring pipe, a flexible joint of the feeding pipe is movably connected with an arm head feeding channel, such that the concrete or mortar enters the nozzle for concrete printing or grouting through the arm head feeding channel, the feeding pipe is fixedly connected with a rotating arm front section, the feeding pipe is connected with an arm head bearing in a sleeving mode, the force bearing end and the feeding pipe are arranged correspondingly, and each of the grouting nozzle or the concrete printing nozzle is provided with a nozzle opening and closing part.

[0012] Optionally, the 3D printing construction apparatus further includes a hoisting structure, the hoisting structure includes a lifting hook, a wire rope and a winch, the lifting hook is arranged below the rotating joint of the printing arm close to the arm head, the winch is arranged below the rotating joint of the printing arm close to the control room, the wire rope is connected between the lifting hook and the winch, and the winch is in communication connection with the controller.

[0013] Optionally, the 3D printing construction apparatus further includes a camera structure, the camera structure includes a camera, the camera is arranged below the rotating joint of the printing arm close to the arm head, and the camera is in communication connection with the controller.

[0014] In a construction method of a 3D printing construction apparatus, when a rapid molding structure and a component need to be printed, a first rotating power part drives an arm head to rotate, a concrete printing nozzle is in pipeline connection with a feed delivery pipe, concrete flows through the feed delivery pipe, such that the concrete printing nozzle sprays the concrete to complete printing of the molding structure and the component; and when slurry needs to be grouted and filled, the first rotating power part drives the arm head to rotate, a grouting nozzle is in pipeline connection with the feed delivery pipe, and the slurry flows through the feed delivery pipe, such that the grouting nozzle sprays the slurry to complete printing of slurry grouting and filling occasions.

[0015] A construction method of a 3D printing construction apparatus includes the following steps:

1) printing of a concrete outer ring layer, specifically, operating a rotary platform of a printing arm structure to rotate, so as to switch to a concrete printing nozzle, such that the concrete printing nozzle rotates downwards, and opening one or a plurality of nozzle opening and closing parts according to a printing width and thickness; and

injecting concrete in a concrete tank into a delivery pump for delivery through a feed delivery pipe, wherein a pipeline passes through a pipeline and line outlet of the rotary platform to deliver the concrete to the concrete printing nozzle along a printing arm for outer ring printing of an anti-collision pier, a built-in program of a controller selects a type and a mix proportion of the concrete to be printed, the built-in program controls a rotating speed of a stirring paddle in a stirring pipe, at the same time, a type and the spray quantity of a liquid sprayed by a nozzle are controlled through a water control valve, the nozzle sprays water or an additive, and then the water or the additive is stirred and mixed by the stirring paddle to prepare concrete to be printed, and at the same time, the nozzle is arranged at one end of the stirring pipe away from the arm head, so that the stirring paddle fully stirs the concrete to be printed after adding the liquid, a driving part of a driving structure drives the stirring paddle to rotate, a planetary gear is arranged on the driving part, a disc gear engaged with the planetary gear is arranged on a stirring shaft, support frames are arranged at two ends, arranged along an axis, of the stirring shaft respectively, the support frames are of arc structures, support bearings are arranged between the support frames and the stirring shaft, when a printing path needs to be adjusted in a different direction, the controller controls a rotating power part to adjust a direction of the printing nozzle, so as to adjust the printing path;

(2) putting a stone wire mesh bag, driving, by the rotary platform, the printing arm to rotate, hoisting the stone wire mesh bag by a lifting hook, putting into the anti-collision pier, and grouting after filling a layer; and

(3) pressurizing by the stone wire mesh bag for grouting, and controlling, by the controller, a first rotating power part to switch to a grouting nozzle for grouting, wherein a feeding pipe is in butt-joint with the grouting nozzle for grouting, the grouting nozzle is made of a flexible metal pipe, after a layer of stones is filled, the grouting nozzle is extended into a gap formed by the stones, a camera observes a grouting effect to stop grouting or adjusting a grouting position, and after a layer of grouting is completed, a second layer of stones is hoisted, so as to complete printing by multi-layer hoisting and layered grouting.

[0016] The technical solution of the present disclosure has the following advantages.

1. The 3D printing construction apparatus provided by the present disclosure includes: the operation structure, including the control room, the controller being arranged in the control room; the printing arm structure, arranged on the side of the control room and including the printing arm and the feed delivery pipe, the feed delivery pipe being suitable for flowing of the concrete or the slurry; and the printing arm head structure, arranged at the end of the printing arm structure away from the control room and including the arm head and the first rotating power part, wherein the first rotating power part is in communication connection with the controller, the grouting nozzle and the concrete printing nozzle are arranged at the two opposite ends of the arm head, the diam-

eters of the grouting nozzle and the concrete printing nozzle are different, and the first rotating power part drives the arm head to rotate, so as to drive the grouting nozzle or the concrete printing nozzle to be in pipeline connection with the feed delivery pipe. When the rapid molding structure and the component need to be printed, the first rotating power part drives the arm head to rotate, the concrete printing nozzle is in pipeline connection with the feed delivery pipe, the concrete flows through the feed delivery pipe, such that the concrete printing nozzle sprays the concrete to complete printing of the molding structure and the component; and when the slurry needs to be grouted and filled, the first rotating power part drives the arm head to rotate, the grouting nozzle is in pipeline connection with the feed delivery pipe, and the slurry flows through the feed delivery pipe, such that the grouting nozzle sprays the slurry to complete printing of slurry grouting and filling occasions. Therefore, the problem that the concrete with different performances and flow rates cannot flow out of the 3D printing device is solved, and the complex structures and buildings formed by combining different concrete performances can be printed, so as to adapt to different printing occasions, and facilitate rapid printing of building models of different sizes.

2. According to the 3D printing construction apparatus provided by the present disclosure, the proximity switch is arranged at the arm head, the proximity switch is in communication connection with the controller, and is configured to determine the rotation position of the arm head, and rotation of the arm head is controlled by the proximity switch to realize positioning of the arm head.

3. According to the 3D printing construction apparatus provided by the present disclosure, the first rotating power part is fixedly provided with the rotating end, the arm head is provided with the force bearing end, a rotating belt is arranged between the rotating end and the force bearing end, the rotating end rotates to drive the arm head to rotate, the rotating belt is driven by the rotating end, and the force bearing end is driven by the rotating belt to rotate, so that rotation of the arm head is realized to drive the concrete printing nozzle or the grouting nozzle to be in pipeline connection with the feed delivery pipe.

4. According to the 3D printing construction apparatus provided by the present disclosure, the printing arm includes the at least two rotating joints, the second rotating power part is arranged between the rotating joints, the second rotating power part is in communication connection with the controller, and the second rotating power part is controlled by the controller to drive the adjacent rotating joints to rotate relatively.

5. The 3D printing construction apparatus provided by the present disclosure further includes the trailer, the trailer is arranged at the end of the control room facing away from the printing arm, the trailer is provided with the trailer body, the delivery pump, the concrete tank, the mortar tank, the sequencing valve, the admixture tank, the water tank, the hydraulic control valve and the liquid delivery pump are arranged in the trailer body, the delivery pump is in pipeline connection with the feed delivery pipe, the delivery pump, the sequencing valve, the hydraulic control valve and the liquid delivery pump are in signal connection with the controller respectively, the concrete tank is in pipeline connection with the sequencing valve through the concrete pipe, the mortar tank is in pipeline connection with the sequencing valve through the grouting pipe, the sequencing valve is in pipeline connection with the delivery pump, the output end of the delivery pump is connected with the feed delivery pipe, the admixture tank and the water tank are connected with the hydraulic control valve respectively through the pipelines, the sequencing valve is in pipeline connection with the liquid delivery pump, and the liquid delivery pump is connected with the nozzle through the liquid delivery pipe.

6. According to the 3D printing construction apparatus provided by the present disclosure, the walking structure is arranged below the control room, the control room is rotatably connected with the walking structure, and the walking structure moves forward or backward, and then turns an angle of the control room after reaching a predetermined position.

7. The 3D printing construction apparatus provided by the present disclosure further includes the stirring pipe arranged close to the arm head and connected with the feed delivery pipe, the driving structure, the stirring paddle and the stirring shaft are arranged in the stirring pipe, the two ends of the stirring shaft are connected with the feed delivery pipe through supporting of the support frames, the driving structure drives the stirring shaft to stir, the end of the stirring pipe facing away from the arm head is connected with the liquid delivery pipe, and the liquid delivery pipe is suitable for flowing of the water or the additive, so that the water or the additive in the liquid delivery pipe enters the stirring pipe to form different performances. The stirring pipe is fixed to the printing arm structure through the fixing pier, the feeding pipe is arranged in the arm head cavity of the arm head, the feed delivery pipe is arranged between the feeding pipe and the stirring pipe, the flexible joint of the feeding pipe is movably connected with the arm head feeding channel, such that the concrete or mortar enters the nozzle for concrete printing or grouting through the arm head feeding channel, the feeding pipe is fixedly connected with the rotating arm front section, the feeding pipe is connected with the arm head bearing in the sleeving mode, the force bearing end and the feeding pipe are arranged correspond-

ingly, each of the grouting nozzle or the concrete printing nozzle is provided with the nozzle opening and closing part, and the grouting nozzle or the concrete printing nozzle is opened or closed by the nozzle opening and closing part to form a 3D printing model with a required width or thickness.

8. The 3D printing construction apparatus provided by the present disclosure further includes the hoisting structure, the hoisting structure includes the lifting hook, the wire rope and the winch, the lifting hook is arranged below the rotating joint of the printing arm close to the arm head, the winch is arranged below the rotating joint of the printing arm close to the control room, the wire rope is connected between the lifting hook and the winch, the winch is in communication connection with the controller, and the winch structure may hoist consumables and other items needed for printing the concrete model.

9. The 3D printing construction apparatus provided by the present disclosure further includes the camera structure, the camera structure includes the camera, the camera is arranged below the rotating joint of the printing arm close to the arm head, and the camera is in communication connection with the controller, so as to transmit a captured image to the control room in real time.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] In order to explain specific implementations of the present disclosure or technical solutions in the prior art more clearly, the following will briefly introduce accompanying drawings that need to be used in the description of the specific implementations or the prior art. Obviously, the accompanying drawings in the following description are some implementations of the present disclosure. For those skilled in the art, other accompanying drawings may further be obtained based on these accompanying drawings without creative efforts.

Fig. 1 is a front view of a 3D printing construction apparatus provided in an implementation of the present disclosure.

Fig. 2 is a top view of a 3D printing construction apparatus provided in an implementation of the present disclosure.

Fig. 3 is an enlarged schematic diagram in a direction A shown in Fig. 1.

Fig. 4 is a schematic structural diagram of a rotating joint provided in an implementation of the present disclosure.

Fig. 5 is a schematic structural diagram of a rotating joint provided in an implementation of the present disclosure.

Fig. 6 is a schematic structural diagram of a 3D printing construction apparatus provided in an implementation of the present disclosure.

Fig. 7 is a schematic structural diagram of a stirring pipe provided in an implementation of the present disclosure.

Fig. 8 is a schematic diagram of a hoisting function provided in an implementation of the present disclosure.

[0018] Description of reference numerals: 1. Printing arm structure; 2. Wire rope; 3. Winch; 4. Walking structure; 5. Rotary platform; 51. Cable hole; 52. Active driving gear; 53. Power shaft; 54. Rotary power part; 6. Feed delivery pipe; 61. Concrete pipe; 62. Grouting pipe; 63. Liquid delivery pipe; 7. Trailer rod; 8. Trailer; 9. Stone wire mesh bag; 10. Control room; 11. Power mechanism; 101. Controller; 12. Delivery pump; 13. Sequencing valve; 14. Concrete tank; 141. Mortar tank; 15. Trailer body; 16. Arm head; 161. Grouting nozzle; 162. Concrete printing nozzle; 163. Belt; 164. Force bearing end; 165. Arm head bearing; 17. First rotating power part; 171. Rotating end; 18. Camera; 19. Lifting hook; 20. Rotating joint; 201. Rotating arm front section; 202. Rotating arm rear section; 21. Second rotating power part; 211. Motor seat; 212. Motor shaft; 22. Printing model; 801. Arm head cavity; 802. Feeding pipe; 803. Flexible joint; 804. Nozzle opening and closing part; 805. Arm head feeding channel; 806. Rotating power part; 91. Stirring pipe; 92. Driving structure; 921. Driving part; 922. Disc gear; 923. Planetary gear; 931. Nozzle; 932. Water control valve; 94. Support frame; 941. Support bearing; 95. Stirring paddle; 951. Stirring shaft; 96. Fixing pier; 97. Proximity switch; 98. Admixture tank; 99. Water tank; 100. Liquid delivery pump; and 102. Hydraulic control valve.

DETAILED DESCRIPTION

[0019] The technical solutions of the present disclosure will be described clearly and completely below in combination with the accompanying drawings. Obviously, the described embodiments are part of the embodiments of the present disclosure, not all of them. Based on the embodiments of the present disclosure, all other embodiments obtained by those skilled in the art without creative efforts shall fall within the protection scope of the present disclosure.

[0020] In the description of the present disclosure, it should be noted that directional or positional relationships indicated by terms such as "center", "upper", "lower", "left", "right", "vertical", "horizontal", "inner" and "outer" are based on directional or positional relationships as shown in the accompanying drawings, and are only for the purposes of facilitating describing the present disclosure and simplifying the description, rather than indicating or implying that the referred apparatus or element has to have a specific direction or be constructed and operated in the specific direction, and therefore, they cannot be regarded as limitations to the present disclosure. In addition, the terms "first", "second" and "third" are only used to describe the purposes, and cannot be understood as indicating or implying relative importance.

[0021] In the description of the present disclosure, it should be noted that the terms "mounted", "connected" and "connection" should be understood in a broad sense unless otherwise specified and defined, for example, "connection" may be fixed connection or detachable connection or integrated connection, may be mechanical connection or electric connection, may be direct connection or indirect connection through an intermediate medium, or may be internal connection of two elements. For those ordinary skilled in the art, the specific meanings of the above terms in the present disclosure may be understood in specific situations.

[0022] In addition, the technical features involved in the different implementations of the present disclosure described below may be combined with each other as long as they do not conflict with each other.

Embodiment 1

[0023] A 3D printing construction apparatus provided by the present disclosure includes: an operation structure, including a control room 10, a controller 101 being arranged in the control room 10; a printing arm structure 1, arranged on one side of the control room 10 and including a printing arm and a feed delivery pipe 6, the feed delivery pipe 6 being suitable for flowing of concrete or slurry; and a printing arm head structure, arranged at one end of the printing arm structure 1 away from the control room 10 and including an arm head 16 and a first rotating power part 17, wherein the first rotating power part 17 is in communication connection with the controller 101, a grouting nozzle 161 and a concrete printing nozzle 162 are arranged at two opposite ends of the arm head 16, diameters of the grouting nozzle 161 and the concrete printing nozzle 162 are different, concentrations and proportions of grouted slurry and concrete are also different, and the first rotating power part 17 drives the arm head 16 to rotate, so as to drive the grouting nozzle 161 or the concrete printing nozzle 162 to be in pipeline connection with the feed delivery pipe 6. When a rapid molding structure and a component need to be printed, the first rotating power part 17 drives the arm head 16 to rotate, the concrete printing nozzle 162 is in pipeline connection with the feed delivery pipe 6, concrete flows through the feed delivery pipe 6, such that the concrete printing nozzle 162 sprays the concrete to complete printing of the molding structure and the component; and when slurry needs to be grouted and filled, the first rotating power part 17 drives the arm head 16 to rotate, the grouting nozzle 161 is in pipeline connection with the feed delivery pipe 6, and the slurry flows through the feed delivery pipe 6, such that the grouting nozzle 161 sprays the slurry to complete printing of slurry grouting and filling occasions. Therefore, the problem that different materials cannot flow out of a 3D printing device is solved, so as to adapt to different printing occasions, and building printing models 22 of different sizes can be rapidly printed.

Embodiment 2

[0024] A specific implementation of a 3D printing construction apparatus as shown in Figs. 1-8 includes: a control structure provided with a control room 10, wherein a printing arm structure 1 and a trailer 8 are arranged at two opposite ends of the control room 10 respectively, a walking structure 4 is arranged below the control room 10, and a trailer rod 7 is connected between the walking structure 4 and the trailer 8.

[0025] As shown in Fig. 1, a controller 101 is arranged in the control room 10.

[0026] As shown in Figs. 1-6, the printing arm structure 1 includes a printing arm and a feed delivery pipe 6, wherein the printing arm is composed of two rotating j oints 20, a second rotating power part 21 is arranged between the two rotating joints 20, the second rotating power part 21 is in communication connection with the controller 101, and the controller 101 controls the second rotating power part 21 to drive the adjacent rotating joints 20 to rotate relatively. Specifically, the second rotating power part 21 is a servo motor. As shown in Fig. 6, the rotating joints 20 are divided into a rotating arm front section 201 and a rotating arm rear section 202, the rotating arm front section 201 and the rotating arm rear section 202 are provided with ends, in contact with each other, at a connection position, a motor seat 211 of the second rotating power part 21 is fixedly connected with the rotating arm rear section 202, a motor shaft 212 of the second rotating power part 21 penetrates through a through hole of the rotating arm rear section 202 to be fixedly connected with the rotating arm front section 201, one end of the rotating arm rear section 202 facing away from the second rotating power part 21 is rotatably connected with the rotating arm front section 201, and the motor shaft 212 of the second rotating power part 21 drives the rotating arm front section 201 to perform rotational motion around the rotating arm rear section 202.

[0027] For the convenience of spraying a printing material, as shown in Fig. 1 and Fig. 3, the 3D printing construction apparatus further includes a printing arm head structure, the printing arm head structure is arranged at one end away from the control room 10, the printing arm head structure includes an arm head 16 and a first rotating power part 17, and the first rotating power part 17 is in communication connection with the controller 101. Specifically, the first rotating power part 17 is a servo motor. As shown in Fig. 3, a grouting nozzle 161 and a concrete printing nozzle 162 are arranged at two opposite ends of the arm head 16, and a grouting pipe 62 of the grouting nozzle 161 or a concrete pipe 61 of the concrete printing nozzle 162 is in pipeline connection with the feed delivery pipe 6, wherein a diameter of the concrete printing nozzle 162 is greater than that of the grouting nozzle 161, the quantity of the concrete printing nozzle 162 is 1, and the quantity of the grouting nozzle 161 is 3. In order to drive the arm head 16 to rotate, as shown in Fig. 3, the first rotating power part 17 is fixedly provided with

a rotating end 171, the arm head 16 is provided with a force bearing end 164, and a transmission belt 163 is arranged between the rotating end 171 and the force bearing end 164. A rotation position of the arm head 16 is accurately determined through a proximity switch 97, and a brake apparatus of the rotating end 171 positions the arm head 16 at a printing position.

[0028] If only concrete or mortar is used as a material for 3D printing, it cannot meet requirements of diversified printing structures. Therefore, this patent adopts a design of matched use of two printing materials of the concrete and the mortar. As shown in Fig. 3 and Fig. 8, due to the different mix proportions of the concrete and the slurry, this patent has set up different material storage tanks and different printing nozzles, the material storage tanks are a concrete tank 14 and a mortar tank 141 respectively, and the nozzles are a concrete printing nozzle 162 and a grouting nozzle 161 respectively. In addition, 3D printing concrete should not only meet the requirements of rapid molding, that is, it should be rapidly condensed from the printing nozzle to be prevented from flowing around, but also meet a tight connection between layers of concrete without cold joints, and then 3D printing concrete components or structures are integrated. In addition, a situation that the concrete freely flows in the pipelines and the nozzles without blocking the pipeline and the nozzles further needs to be met. These three points require that the 3D printing concrete is different from traditional concrete, and its raw materials and quality requirements are also different. 3D printing in a factory may be performed in the way of stirring and using at any time, the stirring and using interval is short, a field-use stirring plant and the use aspects are often not in the same place, there is a problem that as the stirring and transportation time between the stirring and use is long, the concrete may have solidified or its performances are not suitable for printing when reaching the site, in order to meet these requirements, this patent sets a tail end adjusting apparatus of a stirring pipe 91, that is, water or additives such as an accelerator and an early strength agent are added before printing, in this way, the needs of long-distance transportation can be met, and the needs of 3D printing can also be met. As shown in Fig. 3 and Fig. 8, the stirring pipe 91 is connected with the feed delivery pipe 6 close to the arm head 16. A stirring paddle 95 and a stirring shaft 951 are arranged in the stirring pipe 91, the stirring shaft 951 is supported by support frames 94 at two ends, a driving structure 92 drives the stirring shaft 951 to stir, a nozzle 931 at a front end atomizes and adds the water or the additives such as the accelerator and the early strength agent, and the stirring pipe 91 is fixed to the printing arm through a fixing pier 96. As shown in Fig. 3, the stirring pipe 91 is connected with a feeding pipe 802 arranged in an arm head cavity 801 of the arm head 16 after being connected with a section of the feed delivery pipe 6, wherein the feeding pipe 802 is a section of short elbow, a head is a flexible joint 803 with a built-in spring to be movably and reliably connected with an arm head feeding channel 805, and slurry leakage during transportation or rotation is avoided, so that the concrete or the mortar enters the nozzle for concrete printing or grouting through the arm head feeding channel 805. At a position in the force bearing end 164 corresponding to the feeding pipe 802, an arm head bearing 165 is arranged on the feeding pipe 802 in a sleeving mode, the feeding pipe 802 is designed to be thickened and strengthened, and a front part is reliably fixed to the rotating arm front section 201, so as to ensure that the arm head 16 can reliably rotate relying on the arm head bearing 165 as a fulcrum when the feeding pipe 802 is fixed while supporting the weight of the arm head 16.

[0029] Both the concrete printing nozzle 162 and the grouting nozzle 161 may be set in the form of multiple nozzles, if the multiple nozzles are adopted, a nozzle opening and closing part 804 is arranged on each small nozzle, so as to control the participation of a single nozzle or the multiple nozzles, so that a width and thickness of printing or a speed of grouting is controlled, a rotary platform and a rotating power part 806 are arranged at a front end of the concrete printing nozzle 162, so as to adjust an angle and a direction of the nozzle in a printing process, thereby adjusting a path. A camera 18 is arranged below the rotating arm front section 201 to perform monitoring and operation adjusting on a working process.

[0030] As shown in Fig. 1 and Fig. 2, a trailer 8 is arranged at one end of the control room 10 facing away from the printing arm, the trailer 8 is provided with a trailer body 15, a delivery pump 12, a concrete tank 14, a mortar tank 141, a sequencing valve 13, an admixture tank 98, a water tank 99, a hydraulic control valve 102 and a liquid delivery pump 100 are arranged in the trailer body 15, the delivery pump 12 is in pipeline connection with the feed delivery pipe 6, the delivery pump 12 and the sequencing valve 13 are in signal connection with the controller 101 respectively, and the hydraulic control valve 102 and the liquid delivery pump 100 are in signal connection with the controller 101 respectively. The concrete tank 14 is in pipeline connection with the sequencing valve 13 through the concrete pipe 61, the mortar tank 141 is in pipeline connection with the sequencing valve 13 through the grouting pipe 62, the sequencing valve 13 is in pipeline connection with the delivery pump 12, and an output end of the delivery pump 12 is connected with the feed delivery pipe 6. Similarly, the admixture tank 98 and the water tank 99 are connected with the hydraulic control valve 102 respectively through pipelines, the hydraulic control valve 102 is in pipeline connection with the liquid delivery pump 100, and the liquid delivery pump 100 is connected with the nozzle 931 through the liquid delivery pipe 63. In addition to the delivery pipeline, a tow bar is further provided with a control line, so that a traction device can control the steering, braking and the like of the trailer.

[0031] In order to drive the control room 10 to rotate, as shown in Fig. 7, the rotary platform 5 is arranged at a top of the walking structure 4, a rotary hole and a cable

hole 51 are formed in the rotary platform 5, a cable is arranged in the cable hole 51, a rotary bearing is arranged in the rotary hole, and the rotary bearing includes a rotary bearing inner ring and a rotary bearing outer ring, wherein the rotary bearing inner ring is fixedly connected with the control room 10, and the rotary bearing outer ring is fixedly connected with the walking structure 4. In order to drive the relative rotation of the walking structure 4 and the control room 10, the 3D printing construction apparatus further includes a power mechanism 11, the power mechanism 11 includes a rotary power part 54, the rotary power part 54 is arranged at a bottom of the control room 10, and a driving end of a power shaft 53 is engaged with an active driving gear 52 assembled outside the rotary platform 5 for driving. The power mechanism 11 not only provides walking power, but also provides power for a whole system of luffing and a lifting hook 19 of the printing structure 1, the liquid delivery pump 100, the delivery pump 12 and the like.

[0032] In order to hoist consumables of a stone wire mesh bag 9 required in a printing model 22, as shown in Fig. 1 and Fig. 3, the 3D printing construction apparatus further includes a hoisting structure, the hoisting structure includes a lifting hook 19, a wire rope 2 and a winch 3, wherein the lifting hook 19 is arranged below the rotating joint 20 of the printing arm close to the arm head 16, the winch 3 is arranged below the rotating joint 20 of the printing arm close to the control room 10, the wire rope 2 is connected between the lifting hook 19 and the winch 3, and the winch 3 is in communication connection with the controller 101.

[0033] In order to capture an image of the printing model 22 during printing, the 3D printing construction apparatus further includes a camera structure, the camera structure includes a camera 18, the camera 18 is arranged at a front end of the printing arm close to the arm head 16, and the camera 18 is in communication connection with the controller 101.

[0034] In a construction method based on a 3D printing construction apparatus, this patent may be used in concrete printing occasions such as road anti-collision piers, but not limited to such occasions. For convenience of explanation, the working principle and implementation steps of this patent are explained by taking printing an anti-collision pier as an example. It specifically includes the following steps:

(1) a concrete outer ring layer is printed. A rotary platform 5 of a printing arm structure is operated to rotate, so as to switch to a concrete printing nozzle 162, such that the concrete printing nozzle 162 rotates downwards. In a rotation process of an arm head 16, a feeding pipe 802 does not rotate, a spring is arranged in a flexible joint 803 of the feeding pipe 802, so that it can be tightly attached to an arc surface of an arm head cavity 801, and it is ensured that there is no slurry leakage, air leakage or liquid leakage. One or a plurality of nozzles are opened according to a printing width and thickness.

An operation device injects concrete in a concrete tank 14 into a delivery pump 12 for delivery through a feed delivery pipe 6, and a pipeline passes through a pipeline and line outlet of the rotary platform 5 to deliver the concrete to the concrete printing nozzle 162 along a printing arm for outer ring printing of the anti-collision pier. A type and a mix proportion of the concrete to be printed are selected according to built-in software in the controller 101 of the control room 10, the built-in program may control a rotating speed of a stirring paddle 95 in a stirring pipe 91 after automatically and accurately calculating, at the same time, a type and the spray quantity of a liquid sprayed by a nozzle 931 are accurately controlled through a water control valve 932, the water or the liquids such as an accelerator and an early strength agent may be sprayed, the nozzle 931 is an atomizing nozzle to make the liquids be in uniform contact with the concrete, the concrete suitable for transportation is stirred into the concrete suitable for 3D printing through further stirring and fully mixing of the stirring paddle 95, the problem of aggregate separation that may occur during transportation and pipeline delivery may also be eliminated, the printing quality is further ensured, and a plurality of nozzles are configured according to the spray quantity. At the same time, the nozzle 931 is arranged at one end of the stirring pipe 91 away from the arm head, such that the water or an admixture is mixed with the concrete in the feed delivery pipe 6 after being added from a liquid delivery pipe 63, and then is fully stirred through the stirring paddle 95 subsequently, uniform fusion of the water or the admixture and the concrete is realized, and a variety of concrete with different performances is obtained through fusion of the amount of water added or the type of the admixture and the concrete. The stirring paddle 95 is driven by a driving part 921 of a driving structure 92, a planetary gear 923 is mounted at a front end of the driving part 921, and a disc gear 922 engaged with the planetary gear 923 is mounted at a corresponding position of the stirring shaft 951 for transmission. The stirring shaft 951 is fixed through support frames 94 arranged at front and rear ends, the support frames 94 are arc support frames 94 facing a delivery direction of the concrete, so as to better bear a delivery force in a delivery process of the concrete and keep overall stability during running, and the support frames 95 are connected with the stirring shaft 951 through support bearings 941. When a printing path needs to be adjusted in a different direction, the controller 101 controls a rotating power part 806 to adjust a direction of the printing nozzle, so as to adjust the printing path.

(2) A stone wire mesh bag 9 is put, the rotary platform 5 drives the printing arm to rotate, a lifting hook 19

hoists the stone wire mesh bag 9 to put into the anti-collision pier, and grouting is performed after filling a layer.

(3) The stone wire mesh bag 9 performs pressurizing for grouting, the first rotating power part 17 is operated to switch to a grouting nozzle 161 for grouting, at this time, an outlet of the feeding pipe 802 is in butt-joint with an inlet of the grouting nozzle 161, and then grouting may be started. After a layer of stones is filled, the grouting nozzle 161 is extended into a gap, since the nozzle is made of a flexible metal pipe, it may be moderately bent under the premise of ensuring strength to effectively extend into the gap, so as to ensure the grouting in place. A camera is mounted on the printing arm to observe a grouting effect to stop grouting or adjusting a grouting position. After a layer of grouting is completed, a second layer of stones is hoisted, and the problem that the grouting is not in place due to too-thick stone layers is avoided by multi-layer hoisting and layered grouting.

[0035] After the operation is completed, the working of the sequencing valve 13 and the delivery pump 12 is stopped until the operation reaches a next working position. Through the above steps, an overall strength that meets the requirements may be formed through the outer-ring concrete, the internal stones, a wire mesh and concrete mortar. Through this continuous construction method, the efficiency of construction is ensured, and the influence of process switching on efficiency is avoided.

[0036] According to the 3D printing construction apparatus and the construction method provided by the present disclosure, rapid and efficient printing is realized through the 3D apparatus, the problem of very low efficiency caused by manual stone masonry is well solved, and at the same time, the advantages of economy, simplicity, assembly line and automatic production are realized. The apparatus provided by the present application may conveniently move in a working region and automatically perform concrete printing through the built-in program, and it is suitable for being widely used in water and electricity, construction and other fields.

[0037] The present application has the following advantages in use:

(1) a traditional 3D concrete printing device is innovatively changed from being fixed to being movable, and is transferred from a factory to a construction site for use, so that a problem that the traditional 3D concrete printing device cannot be used on site is solved;

(2) an integration degree is high, concrete printing, construction material hoisting and grouting are integrated, a problem that the traditional 3D concrete printing device can only print a prefabricated formwork is solved, the scope of application is greatly expanded, labor costs are saved, and a construction efficiency is improved;

(3) the walking structure 4 may be a crawler type or a tire type, the construction under complex terrain conditions such as uneven ground may be met by adjusting the printing arm, and flexibility and reliability are realized;

(4) more use functions are realized, and the present application may be used for concrete printing, grouting, hoisting, hauling and the like separately; and

(5) the universality is high, and it may be used for the construction of various small reinforced concrete facilities, with a wide range of applications and high universality.

[0038] As an alternative implementation, the walking structure 4 of the platform may be the crawler type or the tire type.

[0039] As an alternative implementation, the first rotating power part 17 and the second rotating power part 21 may further be other types of motors besides the servo motor.

[0040] As an alternative implementation, the quantity of the concrete printing nozzle 162 may further be 2, 3 or more, and the quantity of the grouting nozzle 161 may further be 1, 2 or more.

[0041] As an alternative implementation, the rotating end 171 and the force bearing end 164 may be driven by means of gear engagement and the like in addition to being driven by the transmission belt.

[0042] Obviously, the above embodiments are only for the purpose of clearly explaining the examples, rather than limiting the implementations. For those ordinarily skilled in the art, other changes or variations in different forms may further be made on the basis of the above description. It is unnecessary and impossible to enumerate all the implementations here. However, the obvious changes or variations arising therefrom are still within the scope of protection of the present disclosure.

Claims

1. A 3D printing construction apparatus, **characterized in** comprising:

an operation structure, comprising a control room (10), a controller (101) being arranged in the control room (10);
a printing arm structure (1), arranged on one side of the control room (10), the printing arm structure (1) comprising a printing arm and a feed delivery pipe (6), and the feed delivery pipe

(6) being suitable for flowing of concrete or slurry; and

a printing arm head structure, arranged at one end of the printing arm structure (1) away from the control room (10), the printing arm head structure comprising an arm head (16) and a first rotating power part (17), wherein the first rotating power part (17) is in communication connection with the controller (101), a grouting nozzle (161) and a concrete printing nozzle (162) are arranged at two opposite ends of the arm head (16), diameters of the grouting nozzle (161) and the concrete printing nozzle (162) are different, the first rotating power part (17) drives the arm head (16) to rotate, so as to drive the grouting nozzle (161) or the concrete printing nozzle (162) to be in pipeline connection with the feed delivery pipe (6).

2. The 3D printing construction apparatus of claim 1, **characterized in that** a proximity switch (97) is arranged on the arm head (16), the proximity switch (97) is in communication connection with the controller (101), and the proximity switch (97) is configured to determine a rotation position of the arm head (16).

3. The 3D printing construction apparatus of claim 1, **characterized in that** the first rotating power part (17) is fixedly provided with a rotating end (171), the arm head (16) is provided with a force bearing end (164), a transmission belt (163) is arranged between the rotating end (171) and the force bearing end (164), and the rotating end (171) rotates to drive the arm head (16) to rotate.

4. The 3D printing construction apparatus of any one of claims 1 to 3, **characterized in that** the printing arm comprises at least two rotating joints (20), a second rotating power part (21) is arranged between the rotating joints (20), and the second rotating power part (21) is in communication connection with the controller (101).

5. The 3D printing construction apparatus of claim 4, **characterized in** further comprising a trailer (8), wherein the trailer (8) is arranged at one end of the control room (10) facing away from the printing arm, the trailer (8) is provided with a trailer body (15), a delivery pump (12), a concrete tank (14), a mortar tank (141), a sequencing valve (13), an admixture tank (98), a water tank (99), a hydraulic control valve (102) and a liquid delivery pump (100) are arranged in the trailer body (15), the delivery pump (12) is in pipeline connection with the feed delivery pipe (6), the delivery pump (12), the sequencing valve (13), the hydraulic control valve (102) and the liquid delivery pump (100) are in signal connection with the controller (101) respectively, the concrete tank (14) is in pipeline connection with the sequencing valve (13) through a concrete pipe (61), the mortar tank (141) is in pipeline connection with the sequencing valve (13) through a grouting pipe (62), the sequencing valve (13) is in pipeline connection with the delivery pump (12), an output end of the delivery pump (12) is connected with the feed delivery pipe (6), the admixture tank (98) and the water tank (99) are connected with the hydraulic control valve (102) respectively through a pipeline, the hydraulic control valve (102) is in pipeline connection with the liquid delivery pump (100), and the liquid delivery pump (100) is connected with a nozzle (931) through a liquid delivery pipe (63).

6. The 3D printing construction apparatus of claim 4, **characterized in that** a walking structure (4) is arranged below the control room (10), and the control room (10) is rotatably connected with the walking structure (4).

7. The 3D printing construction apparatus of claim 6, **characterized in** further comprising a stirring pipe (91) arranged close to the arm head (16) and connected with the feed delivery pipe (6), wherein a driving structure (92), a stirring paddle (95) and a stirring shaft (951) are arranged in the stirring pipe (91), two ends of the stirring shaft (951) are connected with the stirring pipe (91) through supporting of a support frame (94), the driving structure (92) drives the stirring shaft (951) to stir, one end of the stirring pipe (91) facing away from the arm head (16) is connected with the liquid delivery pipe (63), the liquid delivery pipe (63) is suitable for flowing of water or an additive, the stirring pipe (91) is fixed to the printing arm structure (1) through a fixing pier (96), a feeding pipe (802) is arranged in an arm head cavity (801) of the arm head (16), the feed delivery pipe (6) is arranged between the feeding pipe (802) and the stirring pipe (91), a flexible joint (803) of the feeding pipe (802) is movably connected with an arm head feeding channel (805), such that the concrete or mortar enters the nozzle for concrete printing or grouting through the arm head feeding channel (805), the feeding pipe (802) is fixedly connected with a rotating arm front section (201), the feeding pipe (802) is connected with an arm head bearing (165) in a sleeving mode, the force bearing end (164) and the feeding pipe (802) are arranged correspondingly, and each of the grouting nozzle (161) or the concrete printing nozzle (162) is provided with a nozzle opening and closing part (804).

8. The 3D printing construction apparatus of claim 4, **characterized in** further comprising a hoisting structure, wherein the hoisting structure comprises a lifting hook (19), a wire rope (2) and a winch (3), the

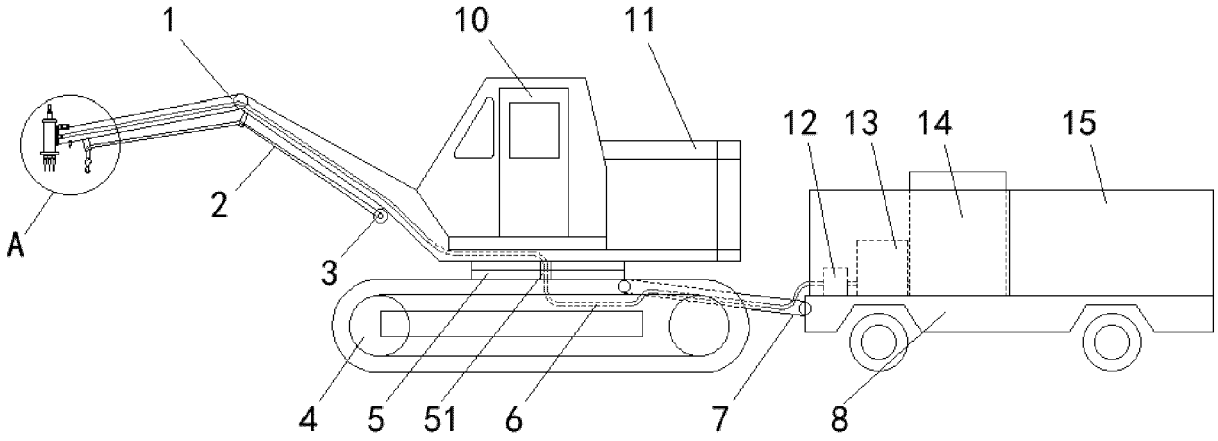
lifting hook (19) is arranged below the rotating joint (20) of the printing arm close to the arm head (16), the winch (3) is arranged below the rotating joint (20) of the printing arm close to the control room (10), the wire rope is connected between the lifting hook (19) and the winch (3), and the winch (3) is in communication connection with the controller (101).

9. The 3D printing construction apparatus of claim 4, **characterized in** further comprising a camera structure, wherein the camera structure comprises a camera (18), the camera (18) is arranged below the rotating joint (20) of the printing arm close to the arm head (16), and the camera (18) is in communication connection with the controller (101).

10. A construction method of a 3D printing construction apparatus, **characterized in that**, when a rapid molding structure and a component need to be printed, a first rotating power part (17) drives an arm head (16) to rotate, a concrete printing nozzle (162) is in pipeline connection with a feed delivery pipe (6), concrete flows through the feed delivery pipe (6), such that the concrete printing nozzle (162) sprays the concrete to complete printing of the molding structure and the component; and when slurry needs to be grouted and filled, the first rotating power part (17) drives the arm head (16) to rotate, a grouting nozzle (161) is in pipeline connection with the feed delivery pipe (6), and the slurry flows through the feed delivery pipe (6), such that the grouting nozzle (161) sprays the slurry to complete printing of slurry grouting and filling occasions.

11. A construction method of a 3D printing construction apparatus, **characterized in** comprising the following steps:

1) printing of a concrete outer ring layer, specifically, operating a rotary platform (5) of a printing arm structure to rotate, so as to switch to a concrete printing nozzle (162), such that the concrete printing nozzle (162) rotates downwards, and opening one or a plurality of nozzle opening and closing parts (804) according to a printing width and thickness;
injecting concrete in a concrete tank (14) into a delivery pump (12) for delivery through a feed delivery pipe (6), wherein a pipeline passes through a pipeline and line outlet of the rotary platform (5) to deliver to the concrete printing nozzle (162) along a printing arm for outer ring printing of an anti-collision pier, a built-in program of a controller (101) selects a type and a mix proportion of the concrete to be printed, the built-in program controls a rotating speed of a stirring paddle (95) in a stirring pipe (91), at the same time, a type and the spray quantity of a liquid sprayed by a nozzle (931) are controlled through a water control valve (932), the nozzle (931) sprays water or an additive, and then the water or additive is stirred and mixed by the stirring paddle (95) to prepare concrete to be printed, at the same time, the nozzle (931) is arranged at one end of the stirring pipe (91) away from the arm head (16), so that the stirring paddle (95) can fully stir the concrete to be printed after adding the liquid, a driving part (921) of a driving structure (92) drives the stirring paddle (95) to rotate, a planetary gear (923) is arranged on the driving part (921), a disc gear (922) meshing with the planetary gear (923) is arranged on a stirring shaft (951), support frames (94) are arranged at two ends, arranged along an axis, of the stirring shaft (951) respectively, the support frames (94) are of arc structures, a support bearing (941) is arranged between the support frames (94) and the stirring shaft (951), when a printing path needs to be adjusted in a different direction, the controller (101) controls a rotating power part (806) to adjust a printing nozzle direction, so as to adjust the printing path;
(2) putting a stone wire mesh bag (9), driving, by the rotary platform (5), the printing arm to rotate, hoisting the stone wire mesh bag (9) by a lifting hook (19), putting into the anti-collision pier, and grouting after filling a layer; and
(3) pressurizing by the stone wire mesh bag (9) for grouting, controlling, by the controller (101), a first rotating power part (17) to switch to a grouting nozzle (161) for grouting, wherein a feeding pipe (802) is in butt-joint with the grouting nozzle (161) for grouting, the grouting nozzle (161) is made of a flexible metal pipe, after a layer of stones is filled, the grouting nozzle (161) is extended into a gap formed by the stones, the camera observes a grouting effect to stop grouting or adjusting a grouting position, and after a layer of grouting is completed, a second layer of stones is hoisted, so as to complete printing by multi-layer hoisting and layered grouting.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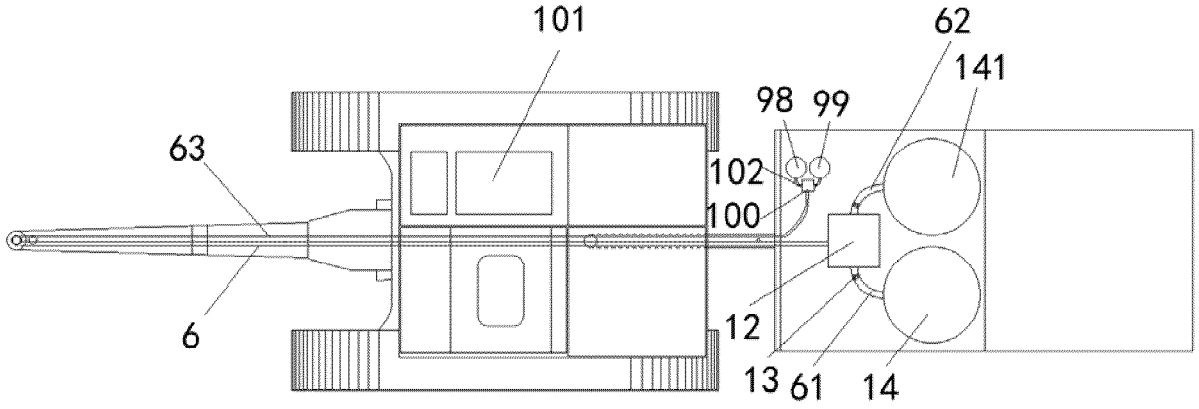
8

Fig.1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102
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13
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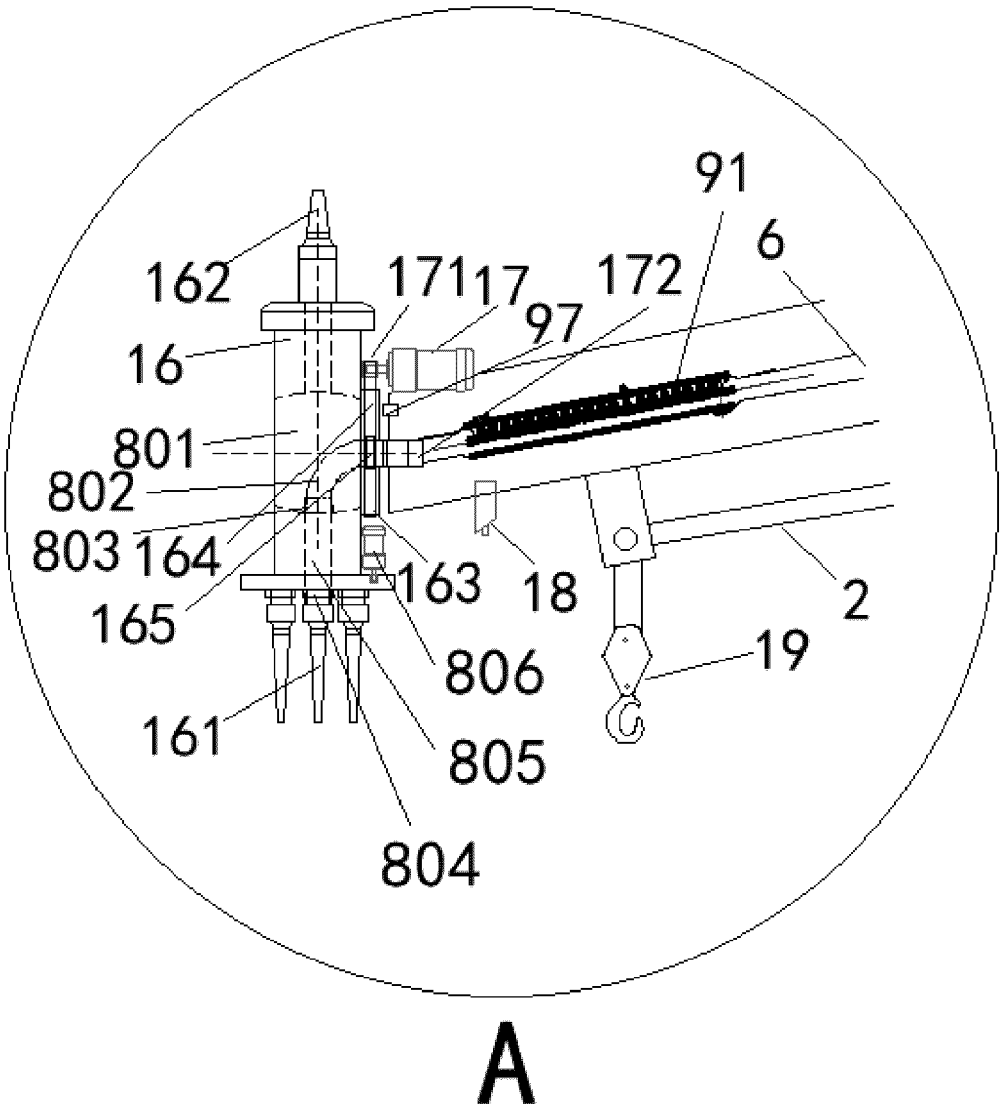
14

Fig. 2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6
162
171
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18
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161
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804
A

Fig. 3

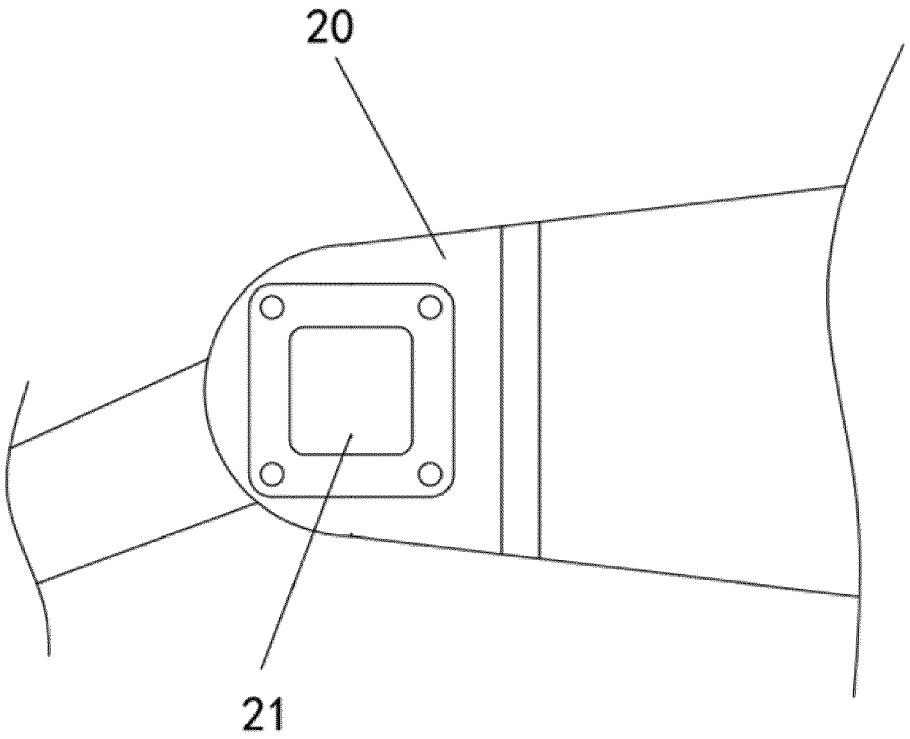

Fig. 4

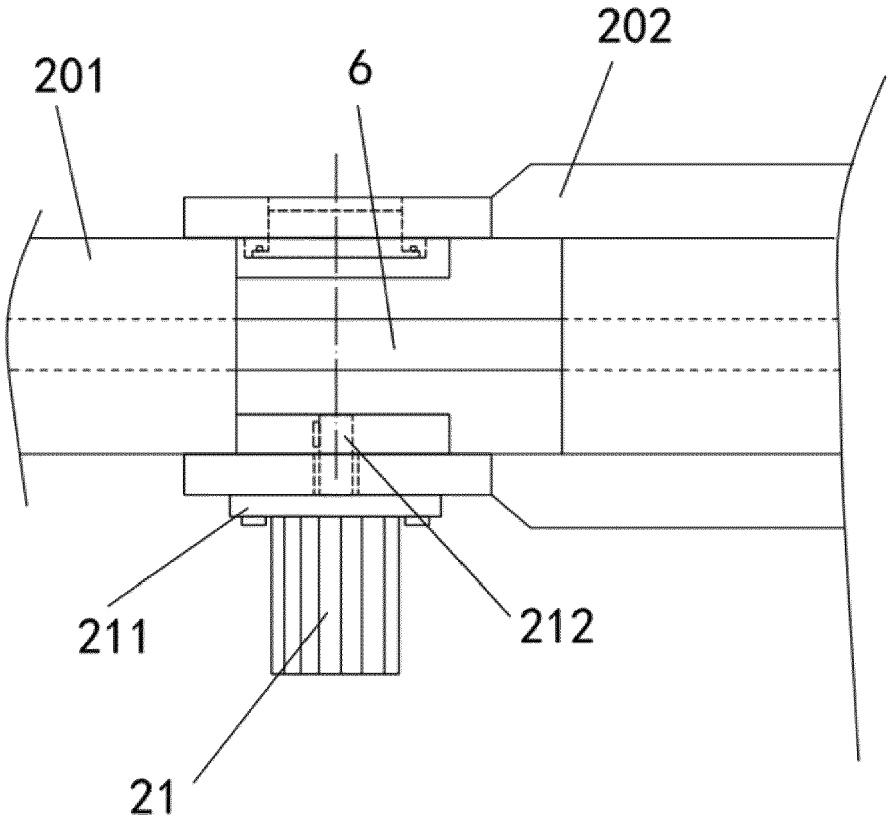

Fig. 5

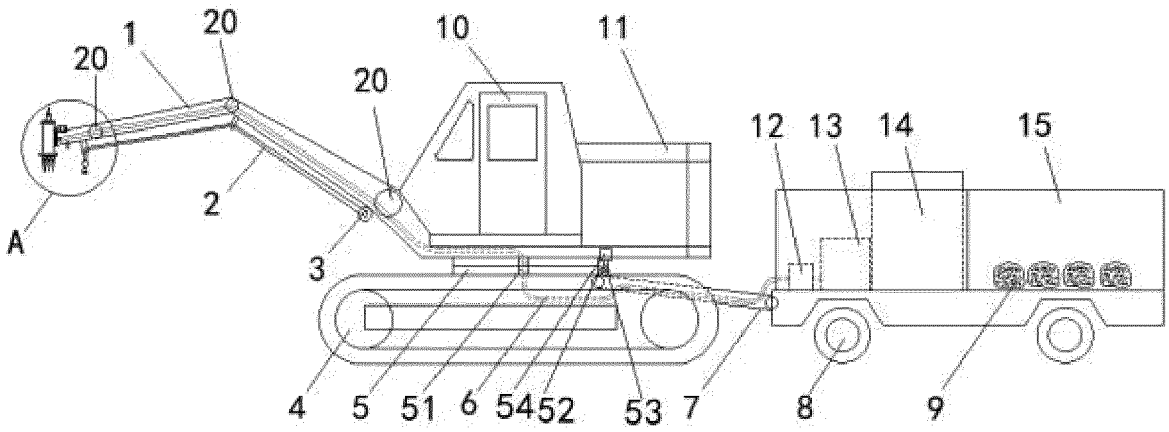

Fig. 6

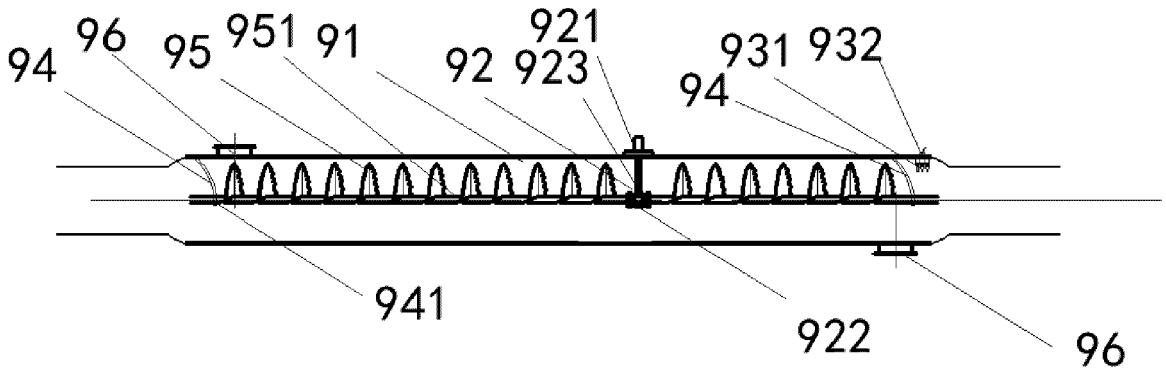

Fig. 7

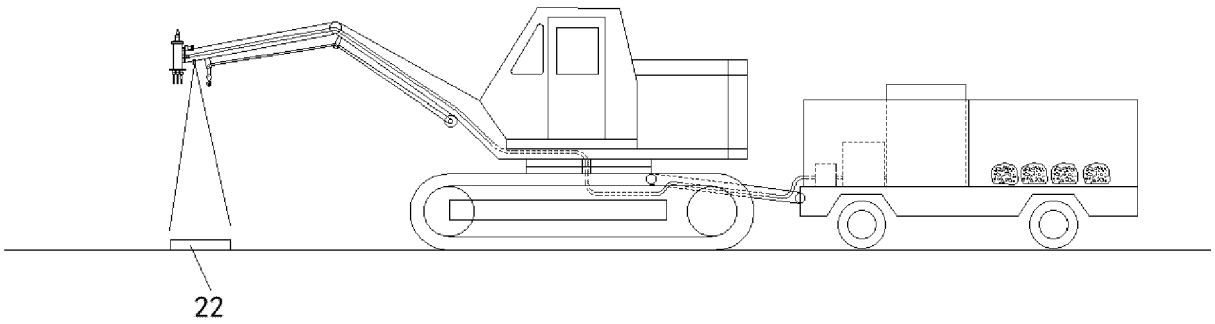

Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 23 16 7658

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	CN 113 478 606 A (SHANGHAI CONSTRUCTION BUILDING MATERIALS TECH GROUP CO LTD ET AL.) 8 October 2021 (2021-10-08) * the whole document *	1-11	ADD. E01C19/48
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TECHNICAL FIELDS SEARCHED (IPC)

B28B
E01C
B29C
E04G
B33Y

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	26 September 2023	Kerouach, May

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26-09-2023

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