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(54) **PACKER AND PILE FOUNDATION STRUCTURE**

(57) Disclosed in the present invention are a packer and a foundation pile structure, relating to the technical field of ocean engineering. The foundation pile structure comprises a foundation pile, a sleeve, and a packer. The sleeve is sleeved on the foundation pile, a gap is reserved between the sleeve and the foundation pile, and an adhesive is filled in the gap. The packer is configured to pack the bottom of the gap between the foundation pile and the sleeve, and the packer comprises a clamp assembly and a cantilever assembly. The clamp assembly is sleeved on the foundation pile and is connected with the bottom of the sleeve, and comprises a plurality of segments, and the segments are connected with each other to form an annular structure; the cantilever assembly comprises a plurality layers of cantilever units stacked on the inner side of the clamp assembly and in the vertical direction, each cantilever unit comprises cantilever members annularly and densely placed at intervals on the inner side of the clamp assembly; and each cantilever member comprises a fixed end and a cantilever end; the fixed ends are connected with the clamp assembly, the

cantilever ends is configured to resist on the foundation pile, and the length value of each cantilever member is not smaller than the difference value between the inner radius of the sleeve and the outer radius of the foundation pile. The present invention has a simple structure, does not need to be controlled by complicated hydraulic power, is convenient to construct, and has low construction cost.

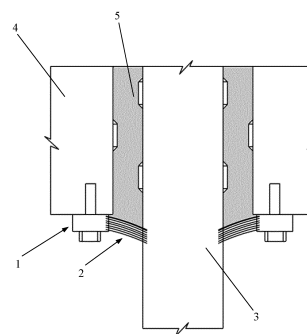


Fig. 1

Description

Field of the Invention

[0001] The present invention relates to the technical field of ocean engineering, and in particular to a packer and a foundation pile structure.

Background of the Invention

[0002] Underwater piling in ocean engineering often uses sleeves to realize the connection between subsea foundation piles and the foundation of the water surface structure, wherein underwater grouting (adhesive injection) operation for the gap between the subsea foundation pile and the sleeve is a key step to realize the connection. In order to ensure that the adhesive slurry hardens smoothly after being poured into the gap, it is necessary to ensure that the adhesive in the gap does not flow violently during the hardening process. Therefore, the packer at the lower end of the sleeve is a key device to prevent the adhesive slurry in the gap from flowing downward under the action of gravity.

[0003] At present, there are hydraulic packers at home and abroad, comprising bladders made of special rubber materials. When the packer needs to be packed, the hydraulic device is used to inject liquid or gas into the bladder, so that the bladder expands to achieve gap packing. Or a simple rubber gasket packer is used, which mainly uses rubber gaskets in the gaps to implement isolation, and the rubber gaskets are fixed by means of bolts.

[0004] The above hydraulic packer has the following shortcomings:

1. Complex structure. The packer works in deep water, so hydraulic control device is usually placed above the water surface for ease of operation. The hydraulic pipeline is long, so faults that are hard to be eliminated are easily occurred, which will make the hydraulic packer fail.

2. During the process of pile driving, since the packer has not yet played the role of isolation, it cannot prevent the mud and sand aroused by piling from entering the gap with the water flow.

3. High cost and construction cost.

[0005] The above simple packer has the following shortcomings:

1. During the process of pile lowering and pile driving, the rubber sealing gasket and the positioning bolt thereof have a great blocking effect on the foundation pile, which is easy to cause the problem of pile jamming, so that the foundation pile cannot pass through the sleeve.

2. During the process of pile lowering and pile driving, the rubber sealing gasket and the positioning bolt thereof have a great blocking effect on the foundation pile, which is further easy to cause damage to the rubber sealing gasket and the positioning bolt thereof.

[0006] In addition, the deformation of the packer is designed according to the ideal void volume, that is, the foundation pile is considered to be located in the center of the sleeve. Once the position of the foundation pile is eccentric, the packer may be damaged, or the gap may not be completely packed, causing slurry leakage.

Summary of the Invention

[0007] In view of the defects existing in the prior art, the purpose of the present invention is to provide a packer and a foundation pile structure, which are configured to solve the problems of complex structure, inconvenient construction, and high cost of the existing packers.

[0008] In order to achieve the above purpose, the present invention adopts the following technical solution: a packer, which is configured to pack the bottom of a gap between a foundation pile and a sleeve, comprising:

a clamp assembly, which is sleeved on the foundation pile and connected with the bottom of the sleeve; the clamp assembly comprises a plurality of segments, and the segments are connected to each other to form an annular structure; and

a cantilever assembly, which comprises a plurality of layers of cantilever units stacked on the inner side of the clamp assembly and in the vertical direction, each cantilever unit comprises cantilever members annularly and densely placed at intervals on the inner side of the clamp assembly, each cantilever member comprises a fixed end and a cantilever end, the fixed ends are connected with the clamp assembly, the cantilever ends are configured to resist on the foundation pile, and the length value of each cantilever member is not smaller than the difference value between the inner radius of the sleeve and the outer radius of the foundation pile.

[0009] On the basis of the above technical solution, each segment comprises:

a bottom plate, which is provided with an end plate at both ends;

a fixed plate, which is arranged on the bottom plate, and the fixed plate is connected with the sleeve;

a mounting plate, which is arranged on the bottom plate, and the mounting plate is provided with mounting holes for mounting the cantilever members at

intervals along the length direction of the bottom plate; and

a limiting plate, which is arranged on the bottom plate, and the limiting plate is configured to limit the movement of the cantilever members.

[0010] On the basis of the above technical solution, the end plates of two adjacent segments are fastened in a welding way.

[0011] On the basis of the above technical solution, the cantilever member is a single steel wire, the fixed end of the single steel wire is provided with an upsetting head, and the size of the upsetting head is larger than that of the mounting hole.

[0012] On the basis of the above technical solution, the cantilever member is a U-shaped steel wire, and the fixed end of the U-shaped steel wire is penetrated and fixed on two mounting holes.

[0013] On the basis of the above technical solution, the surface of the cantilever member is painted with paint or grease.

[0014] On the basis of the above technical solution, the cantilever member is nylon wire or a composite member of steel wire and rubber.

[0015] The present invention further provides a composite packer, which is configured to pack the bottom of a gap between a foundation pile and a sleeve, comprising a plurality of the packers according to claim 1, and the plurality of the packers are stacked in a vertical direction and connected with the bottom of the sleeve.

[0016] The purpose of the present invention is to further provide a foundation pile structure, comprising:

a foundation pile;

a sleeve, which is sleeved on the foundation pile; wherein a gap is reserved between the sleeve and the foundation pile, and an adhesive is filled in the gap; and

a packer, which is configured to pack the bottom of the gap between the foundation pile and the sleeve, and the packer comprises:

- a clamp assembly, which is sleeved on the foundation pile and connected with the bottom of the sleeve; the clamp assembly comprises a plurality of segments, and the segments are connected to each other to form an annular structure; and
- a cantilever assembly, which comprises a plurality layers of cantilever units stacked on the inner side of the clamp assembly and in the vertical direction, each cantilever unit comprises cantilever members annularly and densely placed at intervals on the inner side of the clamp

assembly, the adhesive is configured to fill the gaps between the cantilever members, each cantilever member comprises a fixed end and a cantilever end, the fixed ends are connected with the clamp assembly, the cantilever ends are configured to resist on the foundation pile, and the length value of each cantilever member is not smaller than the difference value between the inner radius of the sleeve and the outer radius of the foundation pile.

[0017] Compared with the prior art, the present invention has the following advantages.

[0018] The packer and the foundation pile structure in the embodiment of the present invention, have no need to be controlled by complicated hydraulic power, and have convenient construction and economical cost. During the process of pile driving, due to the function of the cantilever member, it has the function of preventing the sandy soil aroused by pile driving from entering the gap with the water flow, and because the cantilever member is annularly and densely placed at intervals along the foundation pile, there are small gaps between the cantilever members, then the adhesive slurry can be used to fill up the small gaps between the cantilever members because it is a paste fluid, and can isolate the gap between the foundation pile and the sleeve from seawater.

Description of the Drawings

[0019]

Fig. 1 is a structural schematic diagram of a packer and foundation pile structure in the embodiment of the present invention;

Fig. 2 is a cross-sectional diagram of a packer in the embodiment of the present invention;

Fig. 3 is a structural schematic diagram of a segment of the packer in the embodiment of the present invention;

Fig. 4 is another structural schematic diagram of a segment of the packer in the embodiment of the present invention;

Fig. 5 is a structural schematic diagram of a composite packer in the embodiment of the present invention.

[0020] In the figures: 1. clamp assembly; 11. segment; 111. bottom plate; 112. fixed plate; 113. mounting plate; 114. limiting plate; 115. end plate; 2. cantilever assembly; 21. cantilever member; 211. fixed end; 212. cantilever end; 3. foundation pile; 4. sleeve; 5. adhesive.

Detailed Description of the Embodiments

[0021] The present invention will be further described below in detail with reference to the drawings in combination with the embodiments.

[0022] As shown in Fig. 1, one aspect of the embodiment of the present invention provides a packer, which is configured to pack the bottom of a gap between a foundation pile and a sleeve, comprising: a clamp assembly 1 and a cantilever assembly 2.

[0023] The clamp assembly 1 is sleeved on the foundation pile 3 and connected with the bottom of the sleeve 4; the clamp assembly 1 comprises a plurality of segments 11, and the segments 11 are connected to each other to form an annular structure.

[0024] The cantilever assembly 2 comprises a plurality of layers of cantilever units stacked on the inner side of the clamp assembly 1 and in the vertical direction, each cantilever unit comprises cantilever members 21 annularly and densely placed at intervals on the inner side of the clamp assembly 1, each cantilever member 21 comprises a fixed end 211 and a cantilever end 212, as shown in Fig. 2, the fixed ends 211 are connected with the clamp assembly 1, the cantilever ends 212 are configured to resist on the foundation pile 3, and the length value of each cantilever member 21 is not smaller than the difference value between the inner radius of the sleeve 4 and the outer radius of the foundation pile 3, which is contribute to the cantilever member 21 to tightly resist on the foundation pile 3 even after the cantilever, so as to ensure the packing effect of the packer.

[0025] Specifically, as shown in Fig. 3, each segment 11 comprises: a bottom plate 111, a fixed plate 112, a mounting plate 113 and a limiting plate 114. An end plate 115 is respectively provided at both ends of the bottom plate 111, and the end plates 115 of two adjacent segments 11 are fastened in a welding way. As shown in Fig. 2, the embodiment of the present invention adopts 16 segments, which are connected to each other to form an annular structure. The fixed plate 112 is arranged on the bottom plate 111 and connected with the sleeve 4, and can use various conventional connection methods such as bolts, flanges, welding, etc., so the construction is convenient. The mounting plate 113 is provided on the bottom plate 111, and the mounting plate 113 is provided with mounting holes for mounting the cantilever members 21 at intervals along the length direction of the bottom plate 111. The limiting plate 114 is arranged on the bottom plate 111 and configured to limit the movement of the cantilever member 21, so as to prevent the cantilever member 21 from loosening.

[0026] Compared with the prior art, the packer in the embodiment of the present invention does not need to be controlled by complicated hydraulic power, has simple structure, convenient construction, and low construction cost. In the process of pile lowering and pile driving, since the stiffness of the cantilever member 21 is small, the resistance of the packer to the foundation pile 3 is very

small, which will not lead to the phenomenon of pile jamming. The clamp assembly 1 is not in direct contact with the foundation pile 3, and the cantilever member 21 has a strong deformation recovery ability, so the packer will not be damaged by the foundation pile 3, and the ability to adapt to the eccentricity of the foundation pile 3 is strong. After the pile is lowered, the cantilever member 21 resists on the foundation pile 3, which preliminarily realizes the isolation of the bottom end of the gap during the process of the pile driving, so it has the function of preventing the coarse-grained sandy soil aroused by the pile driving from entering the gap with the water flow. In the process of grouting (adhesive injection), the adhesive is usually a paste fluid containing graded slurry and well-graded aggregates. The densely arranged cantilever member has a large surface area, and the gap between the cantilever members 21 is very small. Due to the adsorption of the adhesive slurry on the surface of the cantilever member 21 and the clamping of the adhesive aggregate by the gap between the cantilever members 21, the densely arranged cantilever members 21 form a whole under the action of the adhesive, so that the rigidity is improved, which can effectively prevent the slurry from leaking.

[0027] In addition, the clamp assembly 1 is connected with the sleeve 4, and the cantilever member 21 is in a deformable state of the cantilever, which can prevent parts with high rigidity of the clamp assembly 1 from being immersed in the range of the pile hole of the foundation pile 3, and the packer as a whole will not hinder the pile lowering and driving operations, or cause the phenomenon of pile jamming, and can further prevent the packer from being damaged during the pile lowering and pile driving operations.

[0028] As a preferred embodiment, as shown in Fig. 3, the cantilever member 21 is a single steel wire, the fixed end 211 of the single steel wire is provided with an upsetting head, and the size of the upsetting head is larger than that of the mounting hole. As shown in Fig. 4, the cantilever member 21 can further be a U-shaped steel wire, and the fixed end 211 of the U-shaped steel wire is penetrated and fixed on two mounting holes. The surface of the single steel wire or the U-shaped steel wire is painted with a paint layer to prevent seawater corrosion. Further, the cantilever member 21 is a nylon wire or a composite member of steel wire and rubber.

[0029] As shown in Fig. 5, another aspect of the embodiment of the present invention further provides a composite packer, which is configured to pack the bottom of a gap between a foundation pile and a sleeve, comprising a plurality of the packers in the above-mentioned embodiment, the plurality of the packers are stacked in a vertical direction and connected with the bottom of the sleeve 4, and the packing effect is increased through superimposing a plurality of the packers.

[0030] As shown in Fig. 1, another aspect of the embodiment of the present invention further provides a foundation pile structure, comprising: a foundation pile 3, a

sleeve 4 and a packer. The sleeve 4 is sleeved on the foundation pile 3, a gap is reserved between the sleeve 4 and the foundation pile 3, and an adhesive 5 is filled in the gap.

[0031] The packer is configured to pack the bottom of the gap between the foundation pile 3 and the sleeve 4, and the packer comprises a clamp assembly 1 and a cantilever assembly 2.

[0032] The clamp assembly 1 is sleeved on the foundation pile 3 and connected with the bottom of the sleeve 4; the clamp assembly 1 comprises a plurality of segments 11, and the segments 11 are connected to each other to form an annular structure.

[0033] The cantilever assembly 2 comprises a plurality layers of cantilever units stacked on the inner side of the clamp assembly 1 and in the vertical direction, each cantilever unit comprises cantilever members 21 annularly and densely placed at intervals on the inner side of the clamp assembly 1, each cantilever member 21 comprises a fixed end 211 and a cantilever end 212, as shown in Fig. 2, the fixed ends 211 are connected with the clamp assembly 1, the cantilever ends 212 are configured to resist on the foundation pile 3, and the length value of each cantilever member 21 is not smaller than the difference value between the inner radius of the sleeve 4 and the outer radius of the foundation pile 3, which is contribute to the cantilever member 21 to tightly resist on the foundation pile 3 even after the cantilever, so as to ensure the packing effect of the packer.

[0034] Compared with the prior art, the foundation pile structure in the embodiment of the present invention does not need to be controlled by complicated hydraulic power, has simple structure, convenient construction, and low construction cost. In the process of pile lowering and pile driving, since the stiffness of the cantilever member 21 is small, the resistance of the packer to the foundation pile 3 is very small, which will not lead to the phenomenon of pile jamming. The clamp assembly 1 is not in direct contact with the foundation pile 3, and the cantilever member 21 has a strong deformation recovery ability, so the packer will not be damaged by the foundation pile 3, and the ability to adapt to the eccentricity of the foundation pile 3 is strong. After the pile is lowered, the cantilever member 21 resists on the foundation pile 3, which preliminarily realizes the isolation of the bottom end of the gap during the process of the pile driving, so it has the function of preventing the coarse-grained sandy soil aroused by the pile driving from entering the gap with the water flow. In the process of grouting (adhesive injection), the adhesive is usually a paste fluid containing graded slurry and well-graded aggregates. The densely arranged cantilever member has a large surface area, and the gap between the cantilever members 21 is very small. Due to the adsorption of the adhesive slurry on the surface of the cantilever member 21 and the clamping of the adhesive aggregate by the gap between the cantilever members 21, the densely arranged cantilever members 21 form a whole under the action of the adhesive, so that

the rigidity is improved, which can effectively prevent the slurry from leaking.

[0035] The present invention is not limited to the above-mentioned embodiments. One skilled in the art may make several improvements and modifications without departing from the principle of the present invention, and these improvements and modifications are further considered to be within the protection scope of the present invention. The contents that are not described in detail in the description belong to the prior art well known by one skilled in the art.

Claims

1. A packer, which is configured to pack the bottom of a gap between a foundation pile and a sleeve, comprising:

a clamp assembly (1), which is sleeved on the foundation pile (3) and connected with the bottom of the sleeve (4); the clamp assembly (1) comprises a plurality of segments (11), and the segments (11) are connected to each other to form an annular structure; and
a cantilever assembly (2), which comprises a plurality layers of cantilever units stacked on the inner side of the clamp assembly (1) and in the vertical direction, each cantilever unit comprises cantilever members (21) annularly and densely placed at intervals on the inner side of the clamp assembly (1), each cantilever member (21) comprises a fixed end (211) and a cantilever end (212), the fixed ends (211) are connected with the clamp assembly (1), the cantilever ends (212) are configured to resist on the foundation pile (3), and the length value of each cantilever member (21) is not smaller than the difference value between the inner radius of the sleeve (4) and the outer radius of the foundation pile (3).

2. The packer according to claim 1, wherein each segment (11) comprises:

a bottom plate (111), which is provided with an end plate (115) at both ends;
a fixed plate (112), which is arranged on the bottom plate (111), and the fixed plate (112) is connected with the sleeve (4);
a mounting plate (113), which is arranged on the bottom plate (111), and the mounting plate (113) is provided with mounting holes for mounting the cantilever members (21) at intervals along the length direction of the bottom plate (111); and
a limiting plate (114), which is arranged on the bottom plate (111), and the limiting plate (114) is configured to limit the movement of the cantilever members (21).

3. The packer according to claim 2, wherein the end plates (115) of two adjacent segments (11) are fastened in a welding way.
4. The packer according to claim 2, wherein the cantilever member (21) is a single steel wire, the fixed end (211) of the single steel wire is provided with an upsetting head, and the size of the upsetting head is larger than that of the mounting hole. 5
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5. The packer according to claim 2, wherein the cantilever member (21) is a U-shaped steel wire, and the fixed end (211) of the U-shaped steel wire is penetrated and fixed on two mounting holes. 15
6. The packer according to claim 4 or claim 5, wherein the surface of the cantilever member (21) is painted with paint or grease.
7. The packer according to claim 1, wherein the cantilever member (21) is nylon wire or a composite member of steel wire and rubber. 20
8. A composite packer, which is configured to pack the bottom of a gap between a foundation pile and a sleeve, comprising a plurality of the packers according to claim 1, and the plurality of the packers are stacked in a vertical direction and connected with the bottom of the sleeve (4). 25
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9. A foundation pile structure, comprising:
 - a foundation pile (3);
 - a sleeve (4), which is sleeved on the foundation pile (3); wherein a gap is reserved between the sleeve (4) and the foundation pile (3), and an adhesive (5) is filled in the gap; and 35
 - a packer, which is configured to pack the bottom of the gap between the foundation pile (3) and the sleeve (4), and the packer comprises: 40
 - a clamp assembly (1), which is sleeved on the foundation pile (3) and connected with the bottom of the sleeve (4); the clamp assembly (1) comprises a plurality of segments (11), and the segments (11) are connected to each other to form an annular structure; and 45
 - a cantilever assembly (2), which comprises a plurality layers of cantilever units stacked on the inner side of the clamp assembly (1) and in the vertical direction, each cantilever unit comprises cantilever members (21) annularly and densely placed at intervals on the inner side of the clamp assembly (1), the adhesive (5) is configured to fill the gaps between the cantilever members (21), each cantilever member (21) 50
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comprises a fixed end (211) and a cantilever end (212), the fixed ends (211) are connected with the clamp assembly (1), the cantilever ends (212) are configured to resist on the foundation pile (3), and the length value of each cantilever member (21) is not smaller than the difference value between the inner radius of the sleeve (4) and the outer radius of the foundation pile (3).

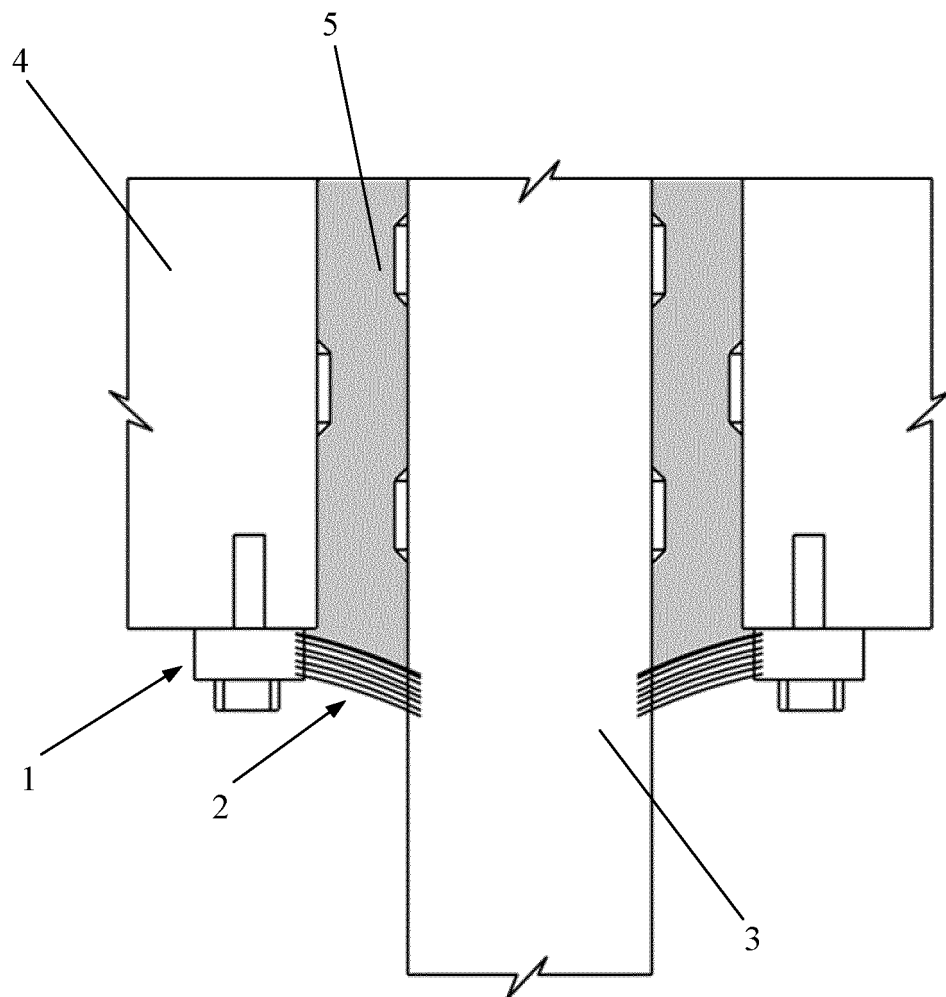


Fig. 1

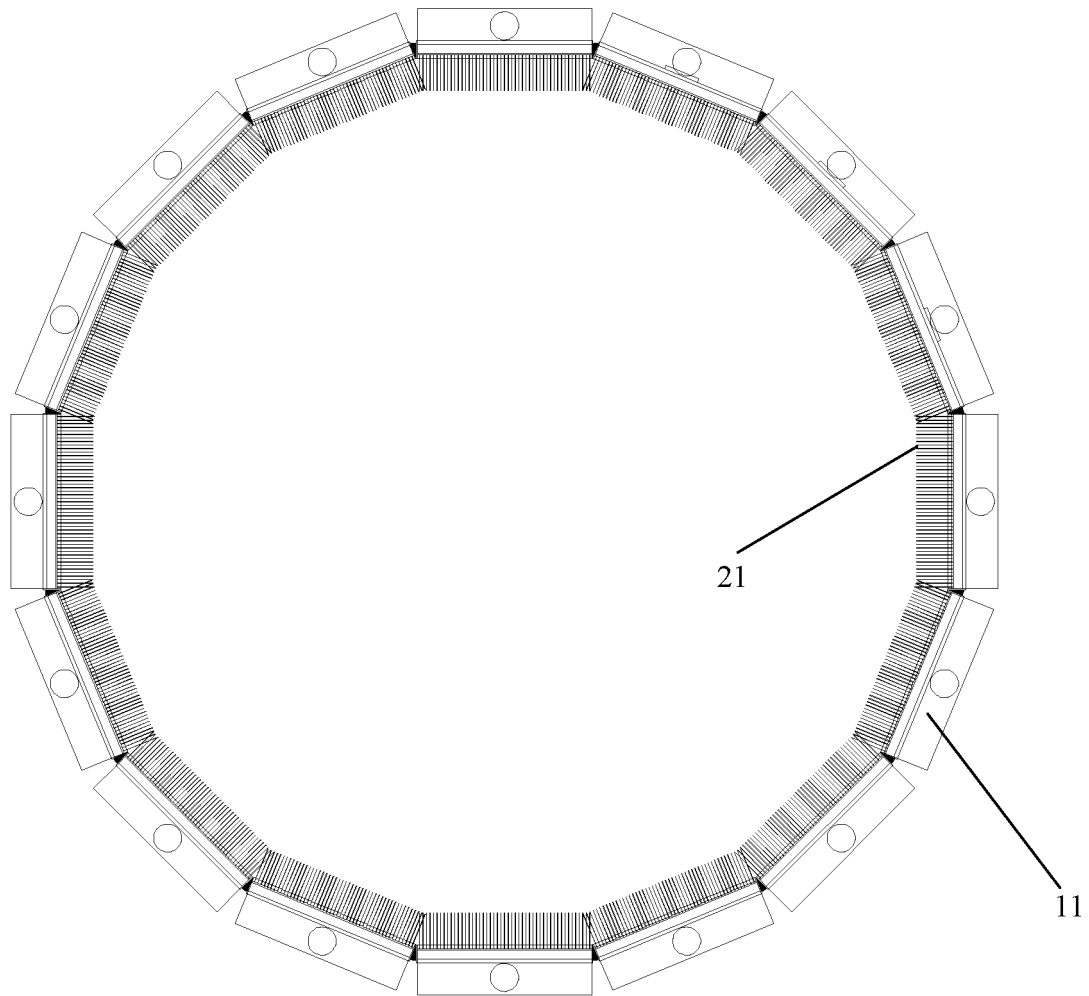


Fig. 2

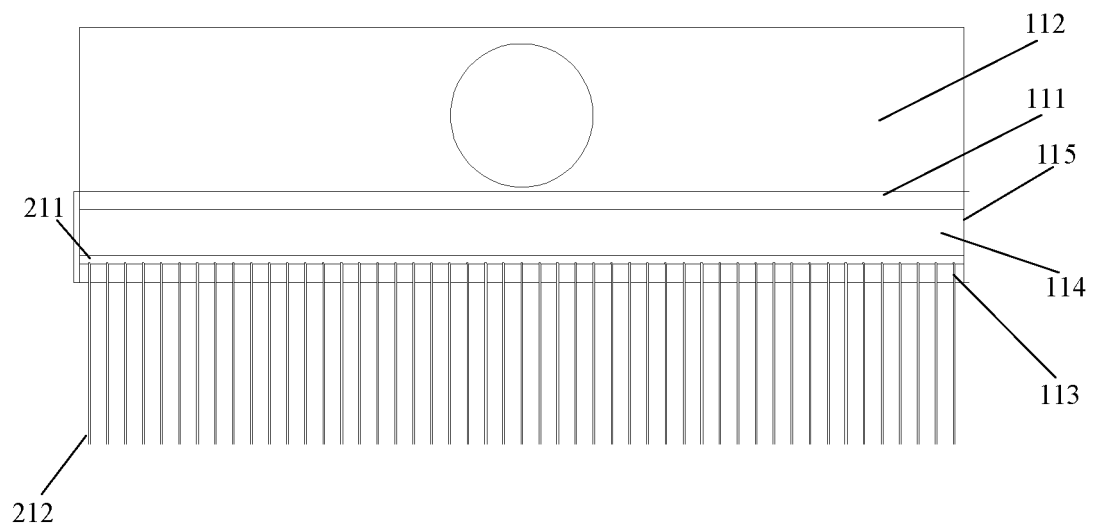


Fig. 3

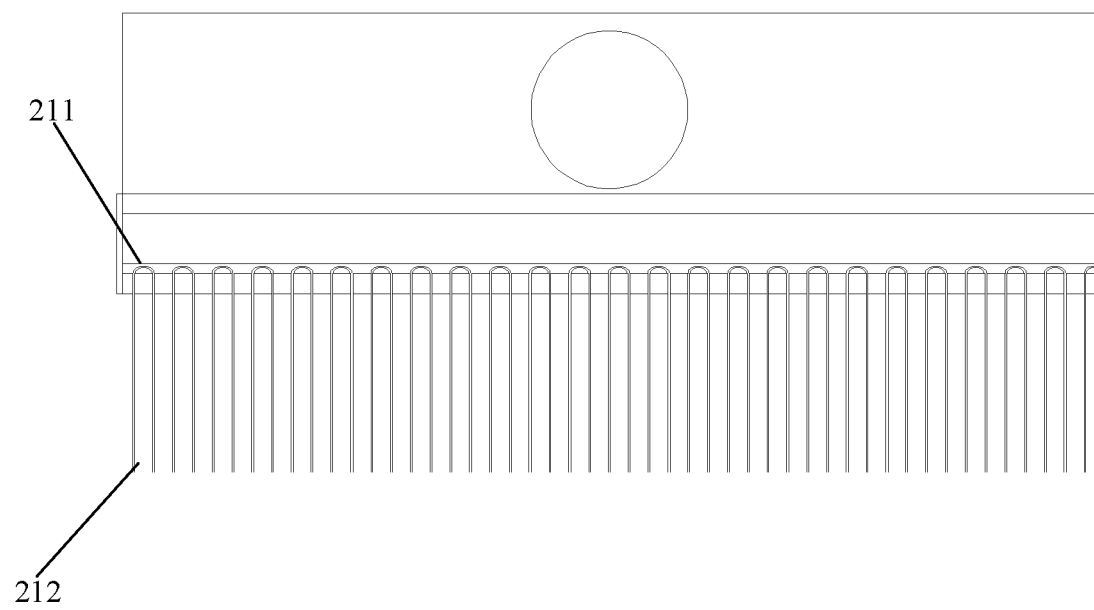


Fig. 4

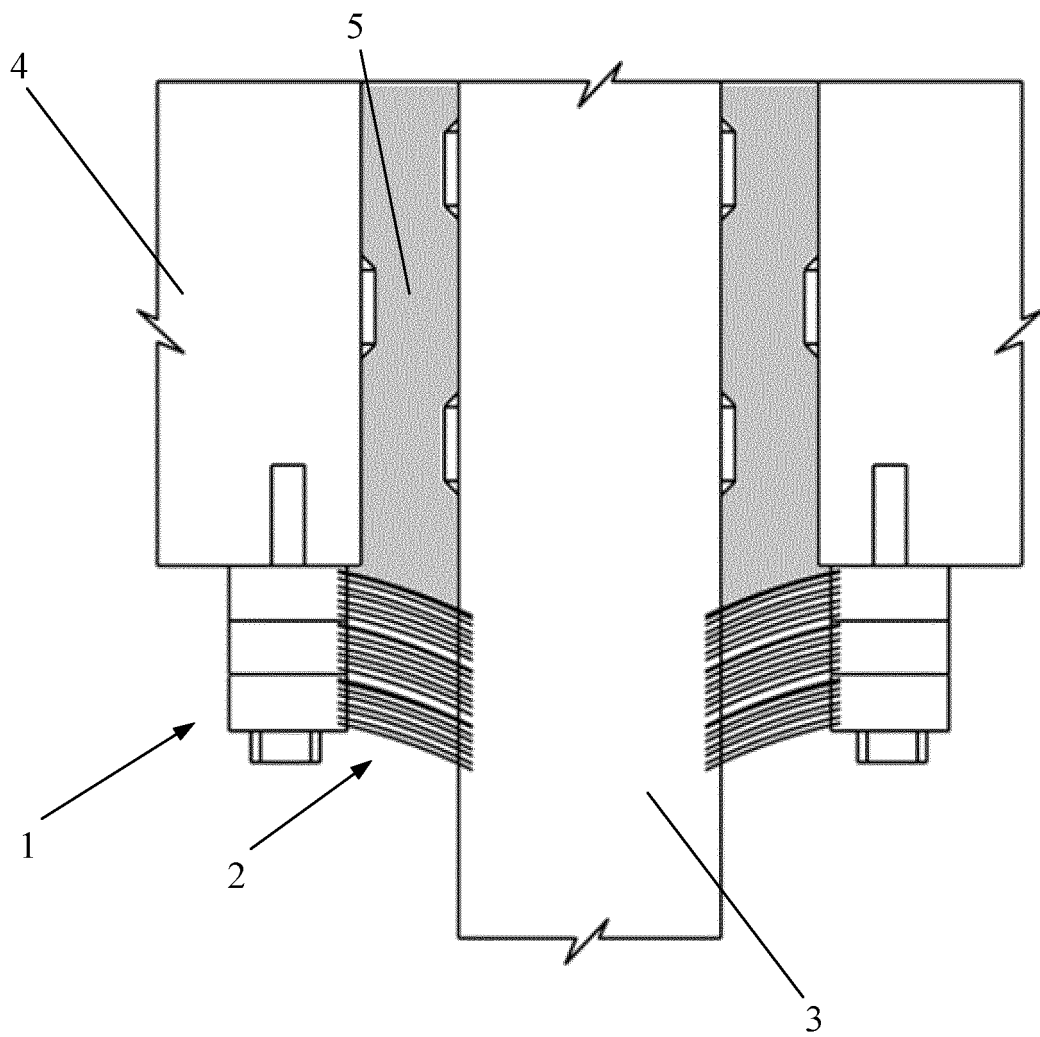


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2020/091013

A. CLASSIFICATION OF SUBJECT MATTER E02D 27/52(2006.01)i; E02B 17/00(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) E02B 17/-; E02D27/-; F03D 11/- Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched																								
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C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>PX</td> <td>CN 110747885 A (CHINA RAILWAY MAJOR BRIDGE RECONNAISSANCE & DESIGN INSTITUTE CO., LTD.) 04 February 2020 (2020-02-04) claims 1-9</td> <td>1-9</td> </tr> <tr> <td>PX</td> <td>CN 110761192 A (CHINA RAILWAY MAJOR BRIDGE RECONNAISSANCE & DESIGN INSTITUTE CO., LTD.) 07 February 2020 (2020-02-07) description, paragraphs [0042]-[0061], and figures 1-4</td> <td>1-9</td> </tr> <tr> <td>A</td> <td>CN 102966117 A (SOUTH CHINA UNIVERSITY OF TECHNOLOGY) 13 March 2013 (2013-03-13) description, paragraphs [0019]-[0025], and figures 1-3</td> <td>1-9</td> </tr> <tr> <td>A</td> <td>CN 104204360 A (CRUX PRODUCTS LTD.) 10 December 2014 (2014-12-10) entire document</td> <td>1-9</td> </tr> <tr> <td>A</td> <td>CN 206128105 U (ZHU, Ronghua) 26 April 2017 (2017-04-26) entire document</td> <td>1-9</td> </tr> <tr> <td>A</td> <td>GB 2524054 A (MARINE CURRENT TURBINES LTD) 16 September 2015 (2015-09-16) entire document</td> <td>1-9</td> </tr> <tr> <td>A</td> <td>EP 2672016 A1 (RWE INNOGY GMBH) 11 December 2013 (2013-12-11) entire document</td> <td>1-9</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	PX	CN 110747885 A (CHINA RAILWAY MAJOR BRIDGE RECONNAISSANCE & DESIGN INSTITUTE CO., LTD.) 04 February 2020 (2020-02-04) claims 1-9	1-9	PX	CN 110761192 A (CHINA RAILWAY MAJOR BRIDGE RECONNAISSANCE & DESIGN INSTITUTE CO., LTD.) 07 February 2020 (2020-02-07) description, paragraphs [0042]-[0061], and figures 1-4	1-9	A	CN 102966117 A (SOUTH CHINA UNIVERSITY OF TECHNOLOGY) 13 March 2013 (2013-03-13) description, paragraphs [0019]-[0025], and figures 1-3	1-9	A	CN 104204360 A (CRUX PRODUCTS LTD.) 10 December 2014 (2014-12-10) entire document	1-9	A	CN 206128105 U (ZHU, Ronghua) 26 April 2017 (2017-04-26) entire document	1-9	A	GB 2524054 A (MARINE CURRENT TURBINES LTD) 16 September 2015 (2015-09-16) entire document	1-9	A	EP 2672016 A1 (RWE INNOGY GMBH) 11 December 2013 (2013-12-11) entire document	1-9
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A	EP 2672016 A1 (RWE INNOGY GMBH) 11 December 2013 (2013-12-11) entire document	1-9																						
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INTERNATIONAL SEARCH REPORT
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PCT/CN2020/091013

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 110747885 A	04 February 2020	None	
CN 110761192 A	07 February 2020	None	
CN 102966117 A	13 March 2013	CN 102966117 B	03 June 2015
CN 104204360 A	10 December 2014	WO 2013057459 A1	25 April 2013
		EP 2769023 A1	27 August 2014
CN 206128105 U	26 April 2017	None	
GB 2524054 A	16 September 2015	GB 201404414 D0	30 April 2014
EP 2672016 A1	11 December 2013	PL 2672016 T3	29 June 2018
		DK 2672016 T3	16 April 2018
		EP 2672016 B1	03 January 2018

Form PCT/ISA/210 (patent family annex) (January 2015)