



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

(43) Date of publication:  
**01.06.2022 Bulletin 2022/22**

(51) International Patent Classification (IPC):  
**E01D 11/04** <sup>(2006.01)</sup> **E01D 19/16** <sup>(2006.01)</sup>

(21) Application number: **20847198.7**

(86) International application number:  
**PCT/CN2020/091010**

(22) Date of filing: **19.05.2020**

(87) International publication number:  
**WO 2021/017581 (04.02.2021 Gazette 2021/05)**

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

(30) Priority: **26.07.2019 CN 201910682688**

(71) Applicant: **China Railway Major Bridge Reconnaissance & Design Institute Co., Ltd.**  
**Wuhan, Hubei 430000 (CN)**

(72) Inventors:  
• **QIN, Shunquan**  
**Wuhan, Hubei 430000 (CN)**  
• **GAO, Zongyu**  
**Wuhan, Hubei 430000 (CN)**  
• **WANG, Heng**  
**Wuhan, Hubei 430000 (CN)**  
• **XU, Wei**  
**Wuhan, Hubei 430000 (CN)**

- **LU, Qinfeng**  
**Wuhan, Hubei 430000 (CN)**
- **FU, Zhangong**  
**Wuhan, Hubei 430000 (CN)**
- **HU, Jun**  
**Wuhan, Hubei 430000 (CN)**
- **ZHENG, Qinggang**  
**Wuhan, Hubei 430000 (CN)**
- **YUAN, Renan**  
**Wuhan, Hubei 430000 (CN)**
- **LI, Shaojun**  
**Wuhan, Hubei 430000 (CN)**
- **FU, Lanlan**  
**Wuhan, Hubei 430000 (CN)**
- **ZHANG, Haoqing**  
**Wuhan, Hubei 430000 (CN)**
- **LI, Yulong**  
**Wuhan, Hubei 430000 (CN)**
- **ZHOU, Ziming**  
**Wuhan, Hubei 430000 (CN)**

(74) Representative: **Harrison, Michael Robert**  
**Thomas Harrison IP Ltd**  
**22 The Grange Road**  
**Leeds LS16 6HA (GB)**

(54) **ANCHORING APPARATUS THAT ADAPTS TO LONGITUDINAL MOVEMENT OF STRUCTURE AND INSTALLATION METHOD**

(57) An anchoring apparatus that adapts to the longitudinal movement of a structure and installation method therefor. The anchoring apparatus that adapts to the longitudinal movement of a structure comprises a flared steel casing tube (1) and a cable guide pipe (8); a cable (6) is threaded through the inside of the cable guide pipe (8), the cable (6) being fixed to an end of the cable guide pipe (8) by means of a cable seal tube (7); the flared steel casing tube (1) is located within the cable guide pipe (8); the inner diameter of the flared steel casing tube (1) gradually lengthens along the direction leading away from the cable seal tube (7); the outer wall of the flared steel casing tube (1) is fixed to the inner wall of the cable guide pipe (8). The installation method for the anchoring apparatus

that adapts to the longitudinal movement of a structure comprises the following steps: machining the flared steel casing tube (1) according to the designed horizontal curve; inserting the flared steel casing tube (1) into the cable guide pipe (8) and fixedly connecting same to the inner wall of the cable guide pipe (8), forming an integral body; threading the cable (6) through the inside of the cable guide pipe (8) and performing tensioning. The anchoring apparatus that adapts to the longitudinal movement of a structure increases the contact area of the outer wall of the cable (6) and the inner wall of the flared steel casing tube (1), preventing part of the cable (6) from being subjected to a concentrated cutting force, improving the safety of the anchoring system.

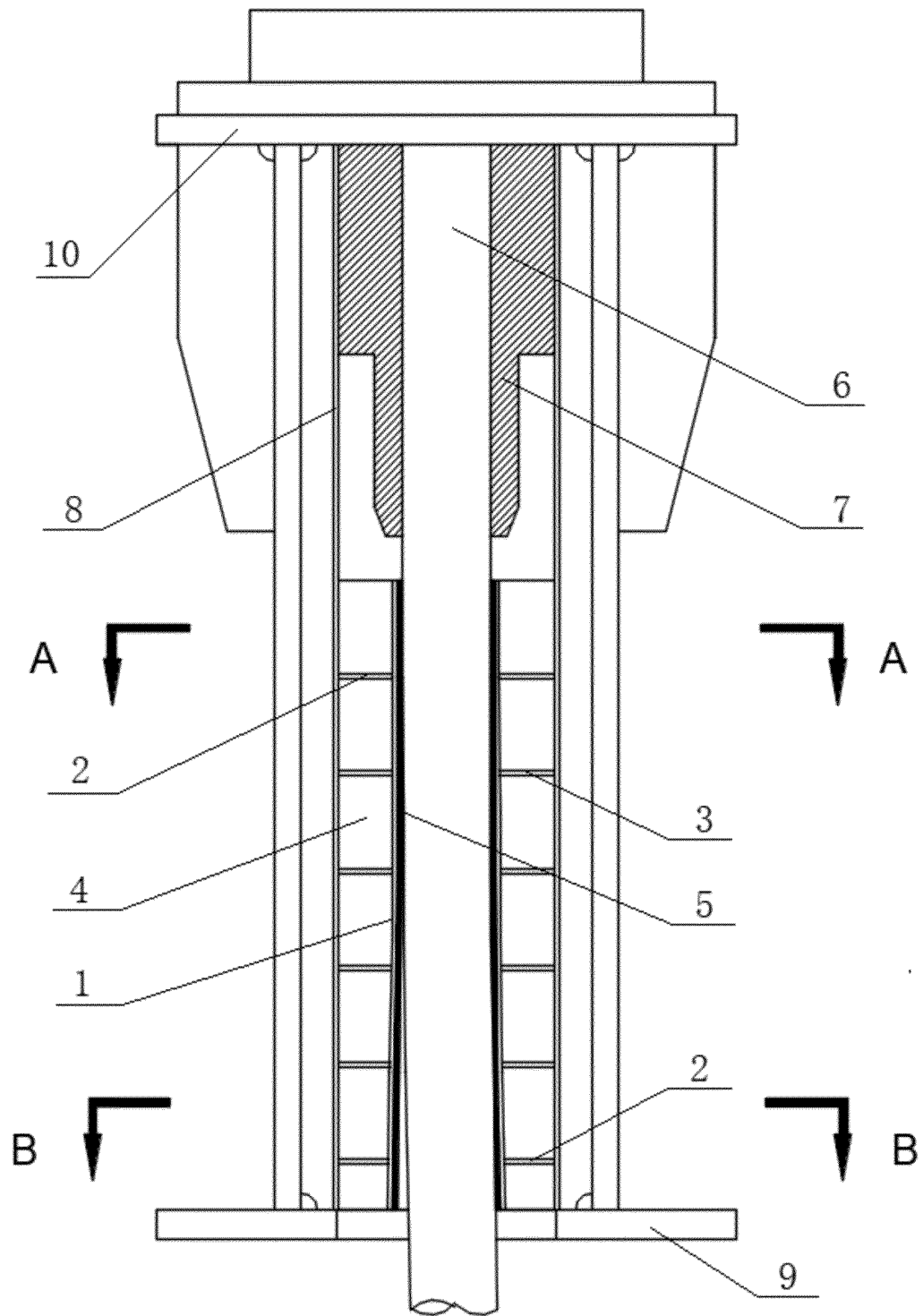


Fig. 1

## Description

### Field of the Invention

**[0001]** The present invention relates to the technical field of bridge anchoring, in particular to an anchoring apparatus that adapts to the longitudinal movement of a structure and installation method therefor.

### Background of the Invention

**[0002]** With the development of cable-stayed bridges at home and abroad, the span thereof is getting larger and larger, and the ratio of main span to side span is also getting larger and larger. The structural system of cable-stayed bridge is complex and there are many influencing factors. The auxiliary piers set in the side span can reduce the length of the cantilever during construction of the side span and increase the overall stiffness of the structure, so as to reduce internal force of main beam, bending moment of tower bottom, deviation of tower top, vertical deformation of main beam and cable stress, and make the stress of the structure tend to a reasonable state. In order to make the stiffness of the main span structure of the cable-stayed bridge not be affected by the bending of the side span main beam, a connecting rod is often set at the anchor point of the side span cable to connect with the lower auxiliary pier, so that the tension generated by the vertical component of the cable force can be directly borne by the auxiliary pier, which reduces the bending of the side span main beam and greatly improves the stiffness of the main span.

**[0003]** However, the treatment of negative reaction of the auxiliary pier of the cable-stayed bridge has always been a key node whether the bridge type scheme is established or not. One of the most efficient and economical schemes is to anchor the main beam to the auxiliary pier column by means of the cable. However, the key problem of this scheme is that if the main beam is longitudinally displaced after anchoring, as shown in Fig. 5, the cable 6 and the end of the cable sealing tube 7 of the anchoring apparatus will be subject to large concentrated cutting force, and if the cable 6 is subject to large concentrated cutting force for a long time, hidden troubles such as wear and fracture are prone to appear, thereby seriously affecting the safety of the anchoring system. Therefore, the existing anchoring scheme can only be applied to small and medium-sized span bridges with small anchoring force and short longitudinal displacement, and cannot meet the needs of the anchoring of the long-span main beam. At present, there is no solution of anchoring structure that can adapt to the longitudinal movement of a structure.

### Summary of the Invention

**[0004]** The purpose of the present invention is to overcome the deficiency of the existing anchoring apparatus

in the above background technology that under the influence of the longitudinal displacement (movement) of the main beam, the cable and the port of the cable sealing tube are subject to a large concentrated cutting force, and if the cable is subject to large concentrated cutting force for a long time, hidden troubles such as wear and fracture are prone to appear, thereby seriously affecting the safety of the anchoring system, so that the present invention provides an anchoring apparatus that adapts to the longitudinal movement of a structure and installation method therefor.

**[0005]** The present invention provides an anchoring apparatus that adapts to the longitudinal movement of a structure, comprising

a cable guiding pipe, a cable is threaded through the inside of the cable guiding pipe, the cable is fixedly connected to an end of the cable guiding pipe by means of a cable sealing tube; and

a flared steel casing tube, the flared steel casing tube is located within the cable guiding pipe, an inner diameter of the flared steel casing tube gradually increases along a direction away from the cable sealing tube; and an outer wall of the flared steel casing tube is fixedly connected to an inner wall of the cable guiding pipe.

**[0006]** Preferred scheme: circumferential stiffeners and radial stiffeners are arranged between the outer wall of the flared steel casing tube and the inner wall of the cable guiding pipe, wherein the circumferential stiffener is circular, the radial stiffener is long strip, and the circumferential stiffener and the radial stiffener are fixedly connected to the outer wall of the flared steel casing tube and the inner wall of the cable guiding pipe.

**[0007]** Preferred scheme: the number of the radial stiffeners is not less than 8, the radial stiffeners are evenly arranged along the circumference of the outer wall of the flared steel casing tube; the number of the circumferential stiffeners is provided with a plurality, the plurality of the circumferential stiffeners are evenly arranged along an axis direction of the flared steel casing tube; and the inner diameter of the plurality of the circumferential stiffeners gradually increases along the direction away from the cable sealing tube, and a distance between two adjacent circumferential stiffeners is not more than 200mm.

**[0008]** Preferred scheme: the axis of the flared steel casing tube is collinear with that of the cable guiding pipe, the inner surface of the flared steel casing tube is formed by a flat curve, composed of a straight line and a circular curve, rotating 360 degrees around the axis of the flared steel casing tube, and the axis distance from the circular curve to the flared steel casing tube is a radius R of the circular curve; and

the inner surface of the flared steel casing tube is provided with a rubber pad, the rubber pad is attached to the inner wall of the flared steel casing tube, and the outer wall of the cable is attached to the rubber pad.

**[0009]** Preferred scheme: the straight line of the flat curve is parallel to the axis of the flared steel casing tube, the length of the straight line is not less than 200mm, and the axial distance from the straight line to the flared steel casing tube is the sum of the radius of the cable, the thickness of the rubber pad and the manufacturing error of 3mm.

**[0010]** Preferred scheme: the straight line of the flat curve is tangent to the circular curve, and the radius of the circular curve is  $R \geq P/q$ , wherein P is a cable force and q is a radial bearing capacity of the flared steel casing tube; and the length of the circular curve is  $L \geq 2SR/H$ , wherein S is a longitudinal displacement of the cable and H is a height difference between upper and lower anchor points of the cable.

**[0011]** Preferred scheme: one end of the cable guiding pipe is welded with an anchor backing plate, the other end of the cable guiding pipe is welded with an anchor sealing plate, both ends of the outer wall of the flared steel casing tube are provided with end circumferential stiffeners, the end circumferential stiffeners are welded with the inner wall of the cable guiding pipe, and the circumferential stiffeners and radial stiffeners are attached to the inner wall of the cable guiding pipe.

**[0012]** Preferred scheme: the flared steel casing tube is located at one end away from the cable sealing tube in the cable guiding pipe, and the flared steel casing tube is located outside the cable sealing tube.

**[0013]** Preferred scheme: the yield strength of structural materials of the flared steel casing tube is not less than 345MPa.

**[0014]** An installation method of the anchoring apparatus that adapts to the longitudinal movement of a structure, comprising the following steps:

composing a cable guiding pipe with a near anchor section and a far anchor section, and the cable guiding pipe is divided into the near anchor section and the far anchor section to facilitate the welding of end circumferential stiffeners with the cable guiding pipe;

processing a flared steel casing tube according to a designed flat curve, and attaching a rubber pad to an inner wall of the flared steel casing tube;

welding radial stiffeners, circumferential stiffeners and end circumferential stiffeners on the outer wall of the flared steel casing tube according to a setting sequence;

sleeving part of the flared steel casing tube into the near anchor section of the cable guiding pipe, and welding the end circumferential stiffeners at one end of the flared steel casing tube with the inner wall of the cable guiding pipe according to a setting position;

sleeving into the far anchor section of the cable guiding pipe, welding the near anchor section and the far

anchor section of the cable guiding pipe into a whole, and ensuring that the axes of the near anchor section and the far anchor section coincide.

welding the end circumferential stiffeners at the other end of the flared steel casing tube with the inner wall of the cable guiding pipe, and forming the flared steel casing tube and the cable guiding pipe as a whole;

welding an anchor backing plate at one end of the cable guiding pipe, and welding an anchor sealing plate at the other end of the cable guiding pipe; and

threading the cable through the inside of the cable guiding pipe for tensioning.

**[0015]** On the basis of the above technical scheme, compared with the prior art, the present invention has the following advantages:

1) The anchoring apparatus that adapts to the longitudinal movement (displacement) of a structure of the present invention, is provided with a flared steel casing tube adapted to the longitudinal movement of the cable in the cable guiding pipe, the inner surface of the flared steel casing tube is formed by a flat curve, composed of a straight line and a circular curve, rotating 360 degrees around the axis of the flared steel casing tube. When the cable moves longitudinally with the main beam, the outer wall of the cable is closely attached to the inner wall of the flared steel casing tube, limiting the movement of the cable and the port of the cable sealing tube, and transferring the concentrated cutting force of the cable and the end of the cable sealing tube to the flared steel casing tube. The flared steel casing tube increases the contact area between the outer wall of the cable and the inner wall of the flared steel casing tube, thereby preventing part of the cable from being subjected to a concentrated cutting force, and improving the safety of the anchoring system.

2) The anchoring apparatus that adapts to the longitudinal movement of a structure of the present invention, is attached to a rubber pad on the inner wall of the flared steel casing tube, and the rubber pad has good flexibility and wear resistance. When the outer wall of the cable contacts the rubber pad, the surface wear of the cable can be significantly reduced and the outer wall of the cable can be protected. The anchoring apparatus welds the radial stiffeners, circumferential stiffeners and end circumferential stiffeners on the outer wall of the flared steel casing tube according to a setting sequence, and the radial stiffeners, circumferential stiffeners and end circumferential stiffeners make the cable guiding pipe and the flared steel casing tube form a whole, thereby significantly improving the structural

strength of the flared steel casing tube, and improving the durability of the flared steel casing tube.

3) The anchoring apparatus that adapts to the longitudinal movement of a structure of the present invention, needs special design in the circular curve section of the flared steel casing tube. The radius R of the circular curve thereof is not less than the ratio of the cable force P to radial bearing capacity q of the flared steel casing tube; and the length L of the circular curve is not less than twice the longitudinal displacement S of the cable multiplied by the radius R of the flared steel casing tube, and then divided by the height difference H between the upper and lower anchor points of the cable. The size and shape of the anchoring apparatus in the flared steel casing tube are accurately calculated by mechanics, which meets the service performance requirements of the anchoring apparatus.

### Brief Description of the Drawings

#### [0016]

Fig. 1 is a structural diagram in the embodiment of the present invention;

Fig. 2 is a sectional view along the A-A direction in Fig. 1;

Fig. 3 is a sectional view along the B-B direction in Fig. 1;

Fig. 4 is a schematic diagram of the longitudinal movement of a cable after adopting the embodiment of the present invention;

Fig. 5 is a schematic diagram of the longitudinal movement of a cable in the background art.

[0017] In the Figures: 1-flared steel casing tube, 2-end circumferential stiffener, 3-circumferential stiffener, 4-radial stiffener, 5-rubber pad, 6-cable, 7-cable sealing tube, 8-cable guiding pipe, 9-anchor sealing plate, 10-anchor backing plate.

### Detailed Description of the Embodiments

[0018] The present invention will be further described below in detail with reference to the drawings in combination with the embodiments.

[0019] It should be noted that, in the case of no conflict, the embodiments and the features in the embodiments of the present invention can be combined with each other. In the following, the technical solutions in the embodiments of the present application will be clearly and completely described with reference to the drawings in the embodiments of the present invention. Obviously, the de-

scribed embodiments are only a part of the embodiments of the present application, not all of the embodiments. The following description of at least one exemplary embodiment is actually merely illustrative and in no way serves as any limitation on the present invention and its application or use. Based on the embodiments in the present invention, all other embodiments obtained by a person of ordinary skill in the art without inventive efforts shall fall within the protection scope of the present invention.

#### Embodiment 1

[0020] As shown in Figs. 1 to 3, the embodiment of the present invention provides an anchoring apparatus that adapts to the longitudinal movement of a structure, comprising:

a cable guiding pipe 8, the cable guiding pipe 8 is a cylindrical steel pipe structure; a cable 6 is threaded through the inside of the cable guiding pipe 8, and one end of the cable 6 is fixedly connected to an end of the cable guiding pipe 8 by means of a cable sealing tube 7;

a flared steel casing tube 1, the flared steel casing tube 1 is located within the cable guiding pipe 8. The flared steel casing tube 1 is located at one end away from the cable sealing tube 7 in the cable guiding pipe 8, and the flared steel casing tube 1 is located outside the cable sealing tube 7. An inner diameter of the flared steel casing tube 1 gradually increases along a direction away from the cable sealing tube 7, and an outer wall of the flared steel casing tube 1 is fixedly connected to an inner wall of the cable guiding pipe 8. Fig. 2 is a sectional view along the A-A direction in Fig. 1, and Fig. 3 is a sectional view along the B-B direction in Fig. 1. In order to highlight the change difference between the section of the flared steel casing tube 1 in Fig. 3 and the section of the flared steel casing tube 1 in Fig. 2, the section of the flared steel casing tube 1 in Fig. 3 is enlarged rather than the actual size. The axis of the flared steel casing tube 1 is collinear with that of the cable guiding pipe 8, the inner surface of the flared steel casing tube 1 is formed by a flat curve, composed of a straight line and a circular curve, rotating 360 degrees around the axis of the flared steel casing tube 1, and the axis distance from the circular curve to the flared steel casing tube 1 is a radius R of the circular curve.

[0021] The straight line of the flat curve is tangent to the circular curve, and the radius of the circular curve is  $R \geq P/q$ , wherein P is a cable force and q is a radial bearing capacity of the flared steel casing tube; and the length of the circular curve is  $L \geq 2SR/H$ , wherein S is a longitudinal displacement of cable 6 and H is a height difference

between upper and lower anchor points of the cable 6. The straight line of the flat curve is parallel to the axis of the flared steel casing tube 1, the length of the straight line is not less than 200mm, and the axial distance from the straight line to the flared steel casing tube 1 is the sum of the radius of the cable 6, the thickness of the rubber pad 5 and the manufacturing error of 3mm. The inner surface of the flared steel casing tube 1, formed by rotating 360 degrees around the axis of the flared steel casing tube 1 by a straight line, is the transition section of the longitudinal movement of the cable 6. When the cable 6 moves longitudinally, the cable 6 located within the straight line range of the inner surface of the flared steel casing tube 1 does not move longitudinally, that is, the cable 6 and the port of the cable sealing tube 7 are prevented from being subjected to a large concentrated cutting force.

**[0022]** Circumferential stiffeners 3 and radial stiffeners 4 are arranged between the outer wall of the flared steel casing tube 1 and the inner wall of the cable guiding pipe 8, and the circumferential stiffener 3 and the radial stiffener 4 are welded with the outer wall of the flared steel casing tube 1. The number of the radial stiffeners 4 is not less than 8, the radial stiffeners 4 are evenly arranged along the circumference of the outer wall of the flared steel casing tube 1; the number of the circumferential stiffeners 3 is provided with a plurality, the number of the circumferential stiffeners 3 is determined by the length of the flared steel casing tube 1, the plurality of the circumferential stiffeners 3 are evenly arranged along the axis direction of the flared steel casing tube 1; and the inner diameter of the plurality of the circumferential stiffeners 3 gradually increases along the direction away from the cable sealing tube 7, and a distance between two adjacent circumferential stiffeners 3 is not more than 200mm.

**[0023]** A rubber pad 5, the thickness thereof is about 10mm, and is attached to the inner wall of the flared steel casing tube 1. When the cable 6 moves longitudinally, the outer wall of the cable 6 is attached to the rubber pad 5.

#### Working Mechanism

**[0024]** The present invention relates to an anchoring apparatus that adapts to the longitudinal movement of a structure. The anchoring apparatus is provided with a flared steel casing tube 1 adapted to the longitudinal movement (displacement) of the cable 6 in the cable guiding pipe 8. The inner surface of the flared steel casing tube 1 is formed by a flat curve, composed of a straight line and a circular curve, rotating 360 degrees around the axis of the flared steel casing tube 1. When the cable 6 moves longitudinally with the main beam, the outer wall of the cable 6 is closely attached to the inner wall of the flared steel casing tube 1, limiting the movement of the cable 6 and the port of the cable sealing tube 7, and transferring the concentrated cutting force of the cable 6

and the port of the cable sealing tube 7 to the flared steel casing tube 1. As shown in Fig. 4, the flared steel casing tube 1 increases the contact area between the outer wall of the cable 6 and the inner wall of the flared steel casing tube 1, thereby preventing part of the cable 6 from being subjected to a concentrated cutting force, and improving the safety of the anchoring system.

**[0025]** In order to improve the structural strength of the flared steel casing tube 1, the anchoring apparatus welds the radial stiffeners 4, circumferential stiffeners 3 and end circumferential stiffeners 2 on the outer wall of the flared steel casing tube 1 according to a setting sequence. The radial stiffeners 4, circumferential stiffeners 3 and end circumferential stiffeners 2 form make the cable guiding pipe 8 and the flared steel casing tube 1 form a whole, thereby significantly improving the structural strength of the flared steel casing tube 1, and improving the durability of the flared steel casing tube 1. In order to reduce the surface wear of the cable 6, the anchoring apparatus is attached to a rubber pad 5 on the inner wall of the flared steel casing tube 1. The rubber pad 5 has good flexibility and wear resistance. When the outer wall of the cable 6 contacts the rubber pad 5, the surface wear of the cable 6 can be significantly reduced and the outer wall of the cable 6 can be protected.

**[0026]** In order to meet the service performance requirements of the anchoring apparatus, the shape and size of the flared steel casing tube 1 are specially designed according to the circular curve section of the flared steel casing tube according to actual engineering requirements. The radius  $R$  of the circular curve thereof is not less than the ratio of the cable force  $P$  to radial bearing capacity  $q$  of the flared steel casing tube; and the length  $L$  of the circular curve is not less than twice the longitudinal displacement  $S$  of the cable multiplied by the radius  $R$  of the flared steel casing tube, and then divided by the height difference  $H$  between the upper and lower anchor points of the cable. The size and shape of the anchoring apparatus in the flared steel casing tube 1 are accurately calculated by mechanics, which meets the service performance requirements of the anchoring apparatus.

**[0027]** Preferred scheme: one end of the cable guiding pipe 8 is welded with an anchor backing plate 10, the other end of the cable guiding pipe 8 is welded with an anchor sealing plate 9, both ends of the outer wall of the flared steel casing tube 1 are provided with end circumferential stiffeners 2, the end circumferential stiffeners 2 are welded with the inner wall of the cable guiding pipe 8, and the circumferential stiffeners 3 and radial stiffeners 4 are attached to the inner wall of the cable guiding pipe 8. The yield strength of structural materials of the flared steel casing tube 1, the end circumferential stiffener 2, the circumferential stiffener 3 and the radial stiffener 4 is not less than 345MPa, so as to improve the radial bearing capacity of the anchoring apparatus.

## Embodiment 2

**[0028]** As shown in Figs. 1 to 3, on the other hand, the present invention provides an installation method of the anchoring apparatus that adapts to the longitudinal movement of a structure, comprising the following steps.

**[0029]** S1: The cable guiding pipe 8 is composed of a near anchor section and a far anchor section. The near anchor section is one end close to the cable sealing tube 7, and the far anchor section is one end away from the cable sealing tube 7. The cable guiding pipe 8 is divided into the near anchor section and the far anchor section to facilitate the welding of end circumferential stiffeners 2 with the cable guiding pipe 8.

**[0030]** S2: The flared steel casing tube 1 is processed according to a designed flat curve, the radius R of the circular curve of the flared steel casing tube 1 is not less than the ratio of the cable force P to radial bearing capacity q of the flared steel casing tube. The length L of the circular curve is not less than twice the longitudinal displacement S of the cable multiplied by the radius R of the flared steel casing tube, and then divided by the height difference H between the upper and lower anchor points of the cable.

**[0031]** S3: After the flared steel casing tube 1 is processed and formed, the inner wall of the flared steel casing tube 1 is attached to a rubber pad 5.

**[0032]** S4: Radial stiffeners 4, circumferential stiffeners 3 and end circumferential stiffeners 2 on the outer wall of the flared steel casing tube 1 are welded according to a setting sequence.

**[0033]** S5: Part of the flared steel casing tube 1 is sleeved into the near anchor section of the cable guiding pipe 8, and the end circumferential stiffeners 2 at one end of the flared steel casing tube 1 close to the cable sealing tube 7 is welded with the inner wall of the cable guiding pipe 8 according to a setting position.

**[0034]** S6: The far anchor section of the cable guiding pipe 8 is sleeved, the near anchor section and the far anchor section of the cable guiding pipe 8 are welded into a whole, and the axes of the near anchor section and the far anchor section are ensured coincide.

**[0035]** S7: The end circumferential stiffeners 2 at the other end of the flared steel casing tube 1 away from the cable sealing tube 7 is welded with the inner wall of the cable guiding pipe 8, and the flared steel casing tube 1 and the cable guiding pipe 8 are formed as a whole.

**[0036]** S8: An anchor backing plate 10 is welded at one end of the cable guiding pipe 8 close to the cable sealing tube 7, and an anchor sealing plate 9 is welded at the other end of the cable guiding pipe 8 away from the cable sealing tube 7.

**[0037]** S9: The cable 6 is threaded through the inside of the cable guiding pipe 8 for tensioning, so as to realize the connection between the main beam and the auxiliary pier.

**[0038]** Those skilled in the art can make various modifications and variations to the present invention. Thus,

in the event that these modifications and variations of the present invention are within the protection scope of the claims and the equivalents thereof, the present invention also intends to comprise such modifications and variations.

**[0039]** 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. An anchoring apparatus that adapts to the longitudinal movement of a structure, comprising

a cable guiding pipe (8), a cable (6) is threaded through the inside of the cable guiding pipe (8), the cable (6) is fixedly connected to an end of the cable guiding pipe (8) by means of a cable sealing tube (7); and

a flared steel casing tube (1), the flared steel casing tube (1) is located within the cable guiding pipe (8), an inner diameter of the flared steel casing tube (1) gradually increases along a direction away from the cable sealing tube (7); and an outer wall of the flared steel casing tube (1) is fixedly connected to an inner wall of the cable guiding pipe (8).

2. The anchoring apparatus that adapts to the longitudinal movement of a structure according to claim 1, wherein

circumferential stiffeners (3) and radial stiffeners (4) are arranged between the outer wall of the flared steel casing tube (1) and the inner wall of the cable guiding pipe (8), wherein the circumferential stiffener (3) is circular, the radial stiffener (4) is long strip, and the circumferential stiffener (3) and the radial stiffener (4) are fixedly connected to the outer wall of the flared steel casing tube (1) and the inner wall of the cable guiding pipe (8).

3. The anchoring apparatus that adapts to the longitudinal movement of a structure according to claim 2, wherein

the number of the radial stiffeners (4) is not less than 8, the radial stiffeners (4) are evenly arranged along the circumference of the outer wall of the flared steel casing tube (1); the number of the circumferential stiffeners (3) is provided with a plurality, the plurality of the circumferential stiffeners (3) are evenly arranged along an axis direction of the flared steel casing tube (1); and the inner diameter of the plurality of the circumferential stiffeners (3) gradually increases along the direction away from the cable sealing tube (7), and a distance between two adjacent circumferential stiffeners (3) is not more than 200mm.

4. The anchoring apparatus that adapts to the longitudinal movement of a structure according to claim 1, wherein

the axis of the flared steel casing tube (1) is col-  
linear with that of the cable guiding pipe (8), the  
inner surface of the flared steel casing tube (1)  
is formed by a flat curve, composed of a straight  
line and a circular curve, rotating 360 degrees  
around the axis of the flared steel casing tube  
(1), and the axis distance from the circular curve  
to the flared steel casing tube (1) is a radius R  
of the circular curve; and  
the inner surface of the flared steel casing tube  
(1) is provided with a rubber pad (5), the rubber  
pad (5) is attached to the inner wall of the flared  
steel casing tube (1), and the outer wall of the  
cable (6) is attached to the rubber pad (5).

5. The anchoring apparatus that adapts to the longitudinal movement of a structure according to claim 4, wherein

the straight line of the flat curve is parallel to the axis  
of the flared steel casing tube (1), the length of the  
straight line is not less than 200mm, and the axial  
distance from the straight line to the flared steel cas-  
ing tube (1) is the sum of the radius of the cable (6),  
the thickness of the rubber pad (5) and the manu-  
facturing error of 3mm.

6. The anchoring apparatus that adapts to the longitudinal movement of a structure according to claim 4, wherein

the straight line of the flat curve is tangent to the  
circular curve, and the radius of the circular curve is  
 $R \geq P/q$ , wherein P is a cable force and q is a radial  
bearing capacity of the flared steel casing tube; and  
the length of the circular curve is  $L \geq 2SR/H$ , wherein  
S is a longitudinal displacement of the cable (6) and  
H is a height difference between upper and lower  
anchor points of the cable (6).

7. The anchoring apparatus that adapts to the longitudinal movement of a structure according to claim 1, wherein

one end of the cable guiding pipe (8) is welded with  
an anchor backing plate (10), the other end of the  
cable guiding pipe (8) is welded with an anchor seal-  
ing plate (9), both ends of the outer wall of the flared  
steel casing tube (1) are provided with end circum-  
ferential stiffeners (2), the end circumferential stiff-  
eners (2) are welded with the inner wall of the cable  
guiding pipe (8), and the circumferential stiffeners  
(3) and radial stiffeners (4) are attached to the inner  
wall of the cable guiding pipe (8).

8. The anchoring apparatus that adapts to the longitudinal movement of a structure according to claim 1,

wherein

the flared steel casing tube (1) is located at one end  
away from the cable sealing tube (7) in the cable  
guiding pipe (8), and the flared steel casing tube (1)  
is located outside the cable sealing tube (7).

9. The anchoring apparatus that adapts to the longitudinal movement of a structure according to claim 1, wherein

the yield strength of structural materials of the flared  
steel casing tube (1) is not less than 345MPa.

10. An installation method of the anchoring apparatus  
that adapts to the longitudinal movement of a struc-  
ture according to any one of claims 1-9,  
comprising the following steps:

composing a cable guiding pipe (8) with a near  
anchor section and a far anchor section, and the  
cable guiding pipe (8) is divided into the near  
anchor section and the far anchor section to fac-  
ilitate the welding of end circumferential stiff-  
eners (2) with the cable guiding pipe (8);

processing a flared steel casing tube (1) accord-  
ing to a designed flat curve, and attaching a rub-  
ber pad (5) to an inner wall of the flared steel  
casing tube (1);

welding radial stiffeners (4), circumferential stiff-  
eners (3) and end circumferential stiffeners (2)  
on the outer wall of the flared steel casing tube  
(1) according to a setting sequence;

sleeving part of the flared steel casing tube (1)  
into the near anchor section of the cable guiding  
pipe (8), and welding the end circumferential  
stiffeners (2) at one end of the flared steel casing  
tube (1) with the inner wall of the cable guiding  
pipe (8) according to a setting position;

sleeving into the far anchor section of the cable  
guiding pipe (8), welding the near anchor section  
and the far anchor section of the cable guiding  
pipe (8) into a whole, and ensuring that the axes  
of the near anchor section and the far anchor  
section coincide; welding the end circumferen-  
tial stiffeners (2) at the other end of the flared  
steel casing tube (1) with the inner wall of the  
cable guiding pipe (8), and forming the flared  
steel casing tube (1) and the cable guiding pipe  
(8) as a whole;

welding an anchor backing plate (10) at one end  
of the cable guiding pipe (8), and welding an  
anchor sealing plate (9) at the other end of the  
cable guiding pipe (8); and

threading the cable (6) through the inside of the  
cable guiding pipe (8) for tensioning.

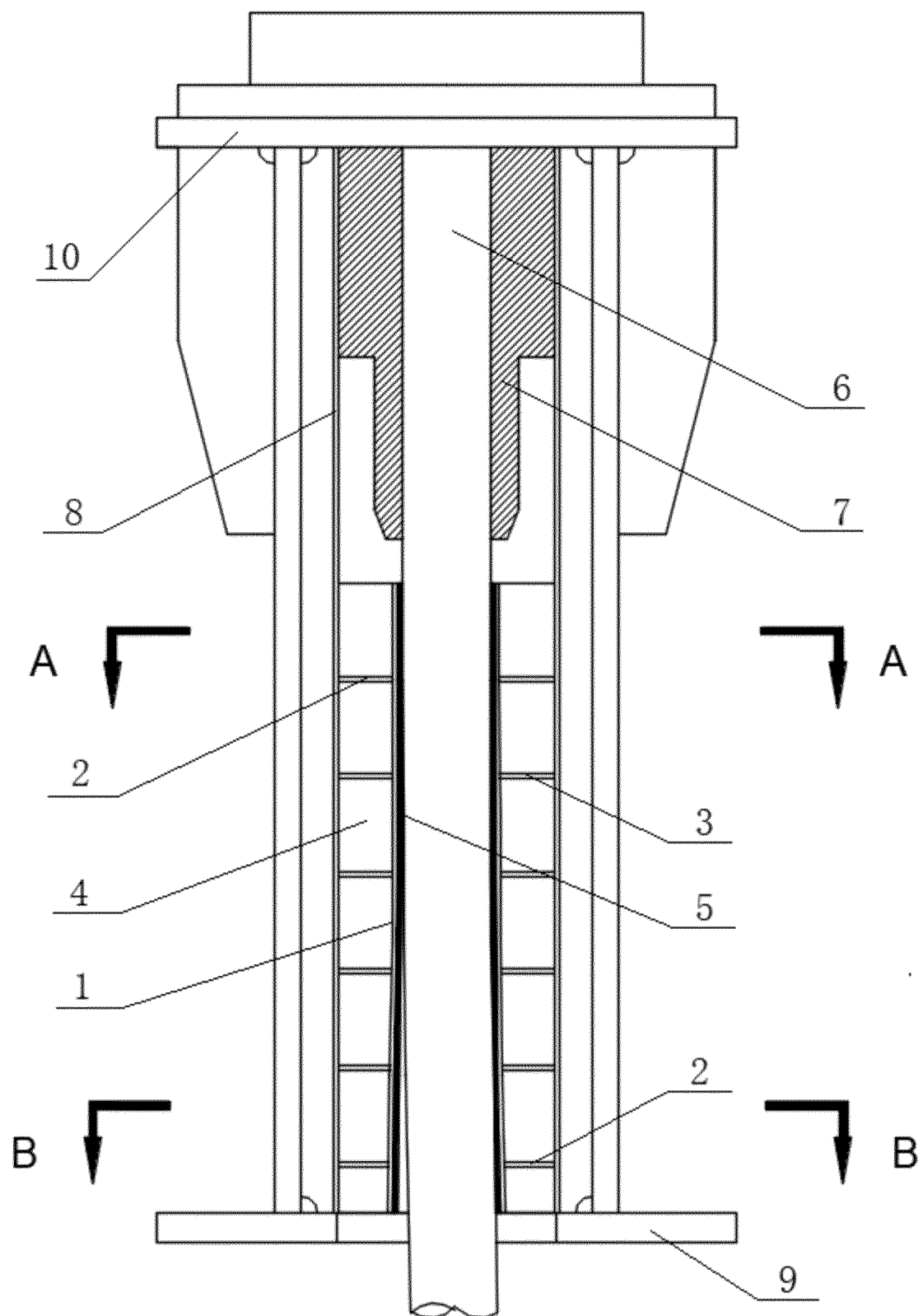


Fig. 1

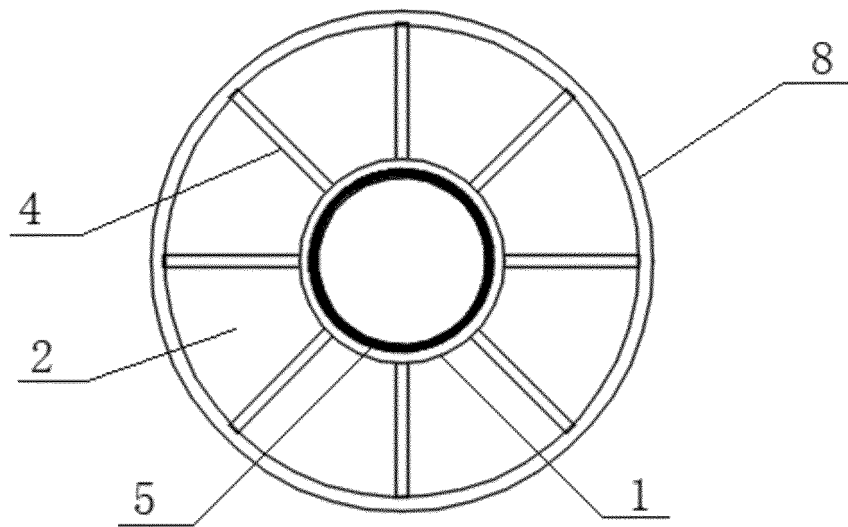


Fig. 2

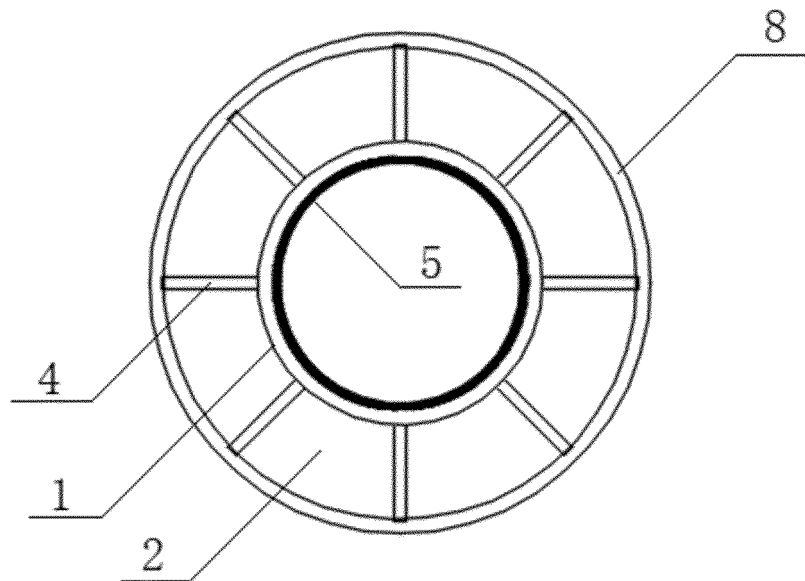


Fig. 3

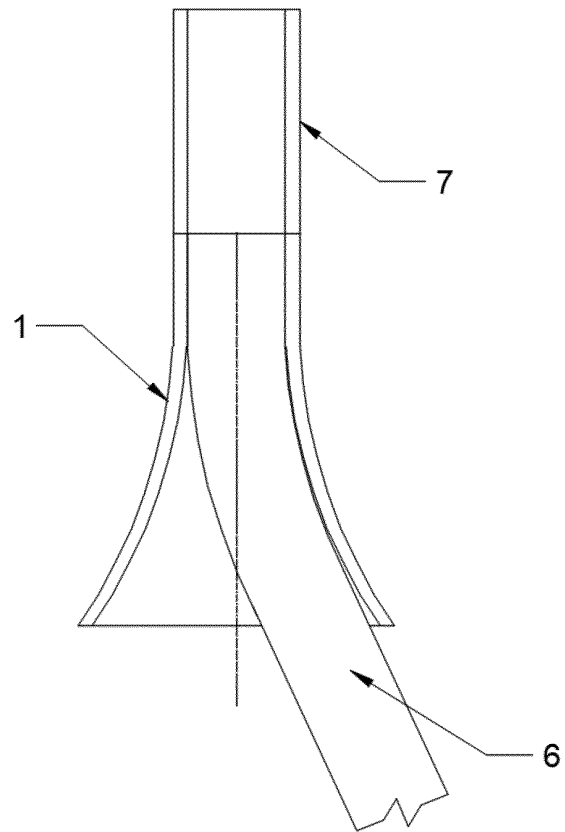


Fig. 4

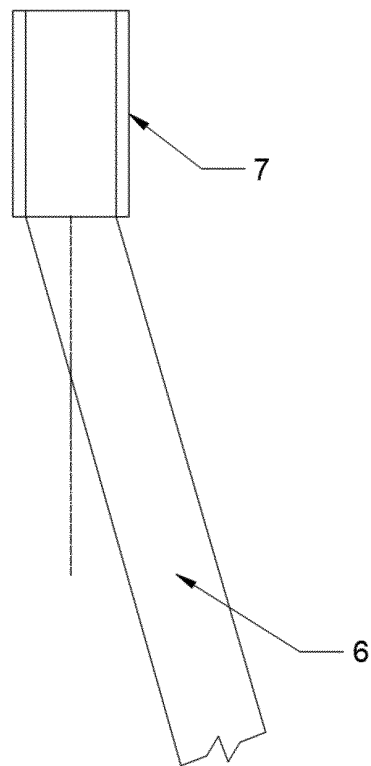


Fig. 5

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2020/091010

| <b>A. CLASSIFICATION OF SUBJECT MATTER</b><br>E01D 11/04(2006.01)i; E01D 19/16(2006.01)i<br><br>According to International Patent Classification (IPC) or to both national classification and IPC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                     |                                                                                    |                                                                                                                                                                                                                                            |                                                                         |                                                                                                                                                |      |    |                                                                                                                                                                     |      |   |                                                                                                                                |      |   |                                                                                                                                       |      |   |                                                                                                                                       |      |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|------|----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|---|--------------------------------------------------------------------------------------------------------------------------------|------|---|---------------------------------------------------------------------------------------------------------------------------------------|------|---|---------------------------------------------------------------------------------------------------------------------------------------|------|
| <b>B. FIELDS SEARCHED</b><br><br>Minimum documentation searched (classification system followed by classification symbols)<br>E01D<br><br>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched<br><br>Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)<br>CNABS, VEN, CNKI: 锚固, 索, 导管, 喇叭, 钢护筒, 切, 割, 肋, anchor+, cable, rope, conduit, pipe, bell-mouthed, shear, cut, incis+, rib                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                     |                                                                                    |                                                                                                                                                                                                                                            |                                                                         |                                                                                                                                                |      |    |                                                                                                                                                                     |      |   |                                                                                                                                |      |   |                                                                                                                                       |      |   |                                                                                                                                       |      |
| <b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b> <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>X</td> <td>DE 2135999 A1 (UNITECTA OBERFLAECHENSCHUTZ et al.) 01 February 1973 (1973-02-01)<br/>description, page 6, line 14 to page 11, line 18, figure 1</td> <td>1-10</td> </tr> <tr> <td>PX</td> <td>CN 110485253 A (CHINA RAILWAY MAJOR BRIDGE RECONNAISSANCE &amp; DESIGN INSTITUTE CO., LTD.) 22 November 2019 (2019-11-22)<br/>description, paragraphs 39-60, figures 1-5</td> <td>1-10</td> </tr> <tr> <td>A</td> <td>CN 108004907 A (XI'AN MUNICIPAL ENGINEERING DESIGN &amp; RESEARCH INSTITUTE CO., LTD.) 08 May 2018 (2018-05-08)<br/>entire document</td> <td>1-10</td> </tr> <tr> <td>A</td> <td>CN 1598211 A (SHANGHAI TUNNEL ENGINEERING &amp; RAIL TRANSIT DESIGN AND RESEARCH INSTITUTE) 23 March 2005 (2005-03-23)<br/>entire document</td> <td>1-10</td> </tr> <tr> <td>A</td> <td>CN 208563108 U (CHINA RAILWAY MAJOR BRIDGE RECONNAISSANCE &amp; DESIGN INSTITUTE CO., LTD.) 01 March 2019 (2019-03-01)<br/>entire document</td> <td>1-10</td> </tr> </tbody> </table> | Category*                                                                                                                                                           | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No.                                                                                                                                                                                                                      | X                                                                       | DE 2135999 A1 (UNITECTA OBERFLAECHENSCHUTZ et al.) 01 February 1973 (1973-02-01)<br>description, page 6, line 14 to page 11, line 18, figure 1 | 1-10 | PX | CN 110485253 A (CHINA RAILWAY MAJOR BRIDGE RECONNAISSANCE & DESIGN INSTITUTE CO., LTD.) 22 November 2019 (2019-11-22)<br>description, paragraphs 39-60, figures 1-5 | 1-10 | A | CN 108004907 A (XI'AN MUNICIPAL ENGINEERING DESIGN & RESEARCH INSTITUTE CO., LTD.) 08 May 2018 (2018-05-08)<br>entire document | 1-10 | A | CN 1598211 A (SHANGHAI TUNNEL ENGINEERING & RAIL TRANSIT DESIGN AND RESEARCH INSTITUTE) 23 March 2005 (2005-03-23)<br>entire document | 1-10 | A | CN 208563108 U (CHINA RAILWAY MAJOR BRIDGE RECONNAISSANCE & DESIGN INSTITUTE CO., LTD.) 01 March 2019 (2019-03-01)<br>entire document | 1-10 |
| Category*                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Citation of document, with indication, where appropriate, of the relevant passages                                                                                  | Relevant to claim No.                                                              |                                                                                                                                                                                                                                            |                                                                         |                                                                                                                                                |      |    |                                                                                                                                                                     |      |   |                                                                                                                                |      |   |                                                                                                                                       |      |   |                                                                                                                                       |      |
| X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | DE 2135999 A1 (UNITECTA OBERFLAECHENSCHUTZ et al.) 01 February 1973 (1973-02-01)<br>description, page 6, line 14 to page 11, line 18, figure 1                      | 1-10                                                                               |                                                                                                                                                                                                                                            |                                                                         |                                                                                                                                                |      |    |                                                                                                                                                                     |      |   |                                                                                                                                |      |   |                                                                                                                                       |      |   |                                                                                                                                       |      |
| PX                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | CN 110485253 A (CHINA RAILWAY MAJOR BRIDGE RECONNAISSANCE & DESIGN INSTITUTE CO., LTD.) 22 November 2019 (2019-11-22)<br>description, paragraphs 39-60, figures 1-5 | 1-10                                                                               |                                                                                                                                                                                                                                            |                                                                         |                                                                                                                                                |      |    |                                                                                                                                                                     |      |   |                                                                                                                                |      |   |                                                                                                                                       |      |   |                                                                                                                                       |      |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | CN 108004907 A (XI'AN MUNICIPAL ENGINEERING DESIGN & RESEARCH INSTITUTE CO., LTD.) 08 May 2018 (2018-05-08)<br>entire document                                      | 1-10                                                                               |                                                                                                                                                                                                                                            |                                                                         |                                                                                                                                                |      |    |                                                                                                                                                                     |      |   |                                                                                                                                |      |   |                                                                                                                                       |      |   |                                                                                                                                       |      |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | CN 1598211 A (SHANGHAI TUNNEL ENGINEERING & RAIL TRANSIT DESIGN AND RESEARCH INSTITUTE) 23 March 2005 (2005-03-23)<br>entire document                               | 1-10                                                                               |                                                                                                                                                                                                                                            |                                                                         |                                                                                                                                                |      |    |                                                                                                                                                                     |      |   |                                                                                                                                |      |   |                                                                                                                                       |      |   |                                                                                                                                       |      |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | CN 208563108 U (CHINA RAILWAY MAJOR BRIDGE RECONNAISSANCE & DESIGN INSTITUTE CO., LTD.) 01 March 2019 (2019-03-01)<br>entire document                               | 1-10                                                                               |                                                                                                                                                                                                                                            |                                                                         |                                                                                                                                                |      |    |                                                                                                                                                                     |      |   |                                                                                                                                |      |   |                                                                                                                                       |      |   |                                                                                                                                       |      |
| <input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                     |                                                                                    |                                                                                                                                                                                                                                            |                                                                         |                                                                                                                                                |      |    |                                                                                                                                                                     |      |   |                                                                                                                                |      |   |                                                                                                                                       |      |   |                                                                                                                                       |      |
| <table border="1"> <tr> <td data-bbox="288 1630 826 1709"> Date of the actual completion of the international search<br/><br/> <b>27 July 2020</b> </td> <td data-bbox="826 1630 1353 1709"> Date of mailing of the international search report<br/><br/> <b>17 August 2020</b> </td> </tr> <tr> <td data-bbox="288 1709 826 1895"> Name and mailing address of the ISA/CN<br/><br/> <b>China National Intellectual Property Administration (ISA/CN)<br/>No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing<br/>100088<br/>China</b><br/><br/> Facsimile No. (86-10)62019451 </td> <td data-bbox="826 1709 1353 1895"> Authorized officer<br/><br/><br/><br/><br/><br/><br/><br/><br/><br/> Telephone No. </td> </tr> </table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Date of the actual completion of the international search<br><br><b>27 July 2020</b>                                                                                | Date of mailing of the international search report<br><br><b>17 August 2020</b>    | Name and mailing address of the ISA/CN<br><br><b>China National Intellectual Property Administration (ISA/CN)<br/>No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing<br/>100088<br/>China</b><br><br>Facsimile No. (86-10)62019451 | Authorized officer<br><br><br><br><br><br><br><br><br><br>Telephone No. |                                                                                                                                                |      |    |                                                                                                                                                                     |      |   |                                                                                                                                |      |   |                                                                                                                                       |      |   |                                                                                                                                       |      |
| Date of the actual completion of the international search<br><br><b>27 July 2020</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Date of mailing of the international search report<br><br><b>17 August 2020</b>                                                                                     |                                                                                    |                                                                                                                                                                                                                                            |                                                                         |                                                                                                                                                |      |    |                                                                                                                                                                     |      |   |                                                                                                                                |      |   |                                                                                                                                       |      |   |                                                                                                                                       |      |
| Name and mailing address of the ISA/CN<br><br><b>China National Intellectual Property Administration (ISA/CN)<br/>No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing<br/>100088<br/>China</b><br><br>Facsimile No. (86-10)62019451                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Authorized officer<br><br><br><br><br><br><br><br><br><br>Telephone No.                                                                                             |                                                                                    |                                                                                                                                                                                                                                            |                                                                         |                                                                                                                                                |      |    |                                                                                                                                                                     |      |   |                                                                                                                                |      |   |                                                                                                                                       |      |   |                                                                                                                                       |      |

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

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2020/091010

| C. DOCUMENTS CONSIDERED TO BE RELEVANT |                                                                                                                      |                       |
|----------------------------------------|----------------------------------------------------------------------------------------------------------------------|-----------------------|
| Category*                              | Citation of document, with indication, where appropriate, of the relevant passages                                   | Relevant to claim No. |
| A                                      | CN 205171369 U (ZHONGJIAO TONGLI CONSTRUCTION CO., LTD.) 20 April 2016 (2016-04-20)<br>entire document               | 1-10                  |
| A                                      | CN 204455824 U (CHINA RAILWAY SIYUAN SURVEY AND DESIGN GROUP CO., LTD.) 08 July 2015 (2015-07-08)<br>entire document | 1-10                  |
| A                                      | JP 2005171604 A (ANDERSON TECHNOLOGY KK) 30 June 2005 (2005-06-30)<br>entire document                                | 1-10                  |
| A                                      | JP 2004353241 A (ORIENTAL KENSETSU KK et al.) 16 December 2004 (2004-12-16)<br>entire document                       | 1-10                  |
| A                                      | KR 20150009721 A (TAESUNG S & I CO., LTD.) 27 January 2015 (2015-01-27)<br>entire document                           | 1-10                  |

**INTERNATIONAL SEARCH REPORT**  
**Information on patent family members**

International application No.

**PCT/CN2020/091010**

| Patent document<br>cited in search report | Publication date<br>(day/month/year) | Patent family member(s) | Publication date<br>(day/month/year) |
|-------------------------------------------|--------------------------------------|-------------------------|--------------------------------------|
| DE 2135999 A1                             | 01 February 1973                     | DE 2135999 C3           | 16 July 1981                         |
|                                           |                                      | DE 2135999 B2           | 18 September 1980                    |
| CN 110485253 A                            | 22 November 2019                     | None                    |                                      |
| CN 108004907 A                            | 08 May 2018                          | None                    |                                      |
| CN 1598211 A                              | 23 March 2005                        | CN 1268818 C            | 09 August 2006                       |
| CN 208563108 U                            | 01 March 2019                        | None                    |                                      |
| CN 205171369 U                            | 20 April 2016                        | None                    |                                      |
| CN 204455824 U                            | 08 July 2015                         | None                    |                                      |
| JP 2005171604 A                           | 30 June 2005                         | None                    |                                      |
| JP 2004353241 A                           | 16 December 2004                     | JP 4212957 B2           | 21 January 2009                      |
| KR 20150009721 A                          | 27 January 2015                      | KR 101546844 B1         | 24 August 2015                       |

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