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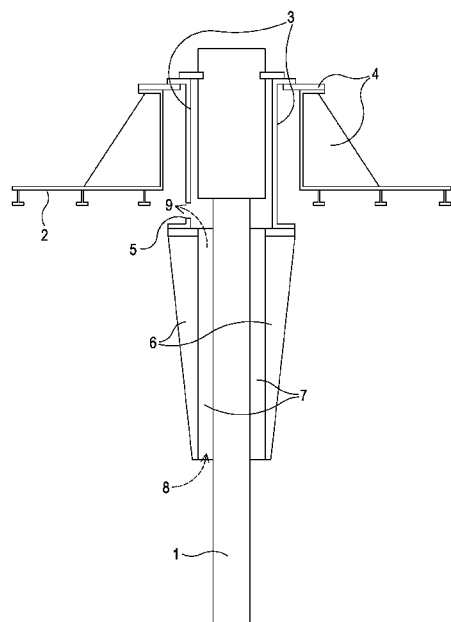


Fig. 1

(57) Abstract: An apparatus comprising: a sleeve defining a bore, wherein a first end portion of the sleeve has a bending stiffness which is larger than the bending stiffness of a second end portion of the sleeve, wherein the bore receives in use an elongate member; a mount connected to a first end of the sleeve, wherein the mount defines an outlet for air or fluids; at least one channel for air or fluid provided along an inside surface of the sleeve, wherein the channel is communicatively connected to the outlet, wherein the channel is defined by a spacer provided within the bore between the elongate member and the sleeve, the spacer comprising a plurality of spacing elements distributed at a plurality of locations around the inner circumference of the bore, and wherein the spacer defines said channel in the longitudinal direction of the sleeve.



Improved Bending Stiffener

Field of the invention

- 5 The invention relates to hydrocarbon drilling, completion and production techniques. In particular, the invention relates to temperature control of bending stiffeners used in offshore applications.

Background

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- Offshore drilling, completion and production relates to the process of creating a wellbore below the seabed and producing hydrocarbons from the well. Although the seabed generally refers to the continental shelf, the devices and methods described herein are equally applicable in lakes, oceans, inshore waters and island seas. The arrangement of facilities in water means that there will be relative movement between the parts which are anchored to the seabed, for example a blow-out preventer, and the facilities which are subject to wave motion or water flow, such as floating platforms, drill ships, or submersibles. Flexible risers, flowlines, cables or umbilicals connect different parts which move relative to each other. The point where a flexible member is connected to the facility, such as a platform, is subject to bending stresses. A riser, for example, generally has a fixed connection to a production platform and the fixed connection does not swivel to compensate for movement of the riser. A bending stiffener can be used to reduce the bending stresses at the connection point. The bending stiffener is a sleeve around the riser while being fixed to the platform at one end. The sleeve has a high stiffness at the fixed end, while gradually having a reduced stiffness towards the other end. One option for varying bending stiffness is gradually reducing the thickness of the material such that the sleeve has a frusto-conical shape, with the thicker end being the fixed end. The sleeve will reduce the stress on the fixed connection between the riser and the platform by reducing the amount of bending of the riser at that point, while gradually allowing more bending of the riser towards the end of the sleeve.
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Statement of invention

According to a first aspect of the invention, there is provided an apparatus comprising:
5 a sleeve defining a bore, wherein a first end portion of the sleeve has a bending stiffness which is larger than the bending stiffness of a second end portion of the sleeve, wherein the bore receives in use an elongate member; a mount connected to a first end of the sleeve, wherein the mount defines an outlet for air or fluids; at least one channel for air or fluid provided along an inside surface of the sleeve, wherein the
10 channel is communicatively connected to the outlet, wherein the channel is defined by a spacer provided within the bore between the elongate member and the sleeve, the spacer comprising a plurality of spacing elements distributed at a plurality of locations around the inner circumference of the bore, and wherein the spacer defines said channel in the longitudinal direction of the sleeve.

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The air channel may be connected to the air outlet. The spacing elements may be tubular members with their longitudinal axis arranged in the longitudinal direction of the sleeve. Further, a plurality of tubular members may be arranged in a longitudinal direction and the plurality of tubular members may be spaced apart from each other in
20 the longitudinal direction. Optionally, the radial cross section of at least one of the tubular members is circular or rectangular.

The spacing elements may be connected to each other by a wire extending in the circumferential direction of the annulus. The wire secures the spacing elements to the
25 elongate member.

Examples of the elongate member are: a riser, a flowline, a cable or an umbilical.

Additionally, a longitudinal air channel may be provided which extends upwards from
30 the outlet. The advantage of this longitudinal channel is that the chimney effect of the air channel is improved and hot air is removed.

Optionally, a pump may be coupled to the channel. The pump provides an advantage of increased air circulation.

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According to a second aspect of the invention, there is provided a spacer for use between a bending stiffener and an elongate member, the spacer comprising: a plurality of spacing elements distributed in a tubular arrangement, and wherein the spacer defines a plurality of channels for air or liquids in the longitudinal direction of the tubular arrangement.

Optionally, the spacing elements comprise a plurality of tubular members, wherein the tubular members are arranged in said tubular arrangement and are connected by a wire in said tubular arrangement, and wherein the longitudinal axis of the tubular members is parallel to the longitudinal direction of the tubular arrangement.

According to a third aspect of the invention, there is provided a method of assembling a spacer around an elongate member, the method comprising: placing a spacer around the circumference of an elongate member, wherein the spacer defines a plurality of channels along the longitudinal direction of the elongate member, and placing a bending stiffener around the spacer. The spacer may be the spacer of the second aspect of the invention. The method according to the third aspect may further comprise securing the tubular members around the elongate member by arranging said wire through openings in the tubular members.

Figures

Some embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings, in which:

Figure 1 illustrates a vertical cross section through a riser with a bending stiffener;

Figure 2 also illustrates a vertical cross section through a riser with a bending stiffener;

Figure 3 illustrates a horizontal cross section and different side views of spacers; and

Figure 4 is a graph of heat drain with a cooling layer.

Specific description

5 The inventors have appreciated that using a bending stiffener may pose a challenge for controlling the temperature of the riser or cable. The stiffener insulates the riser and therefore inhibits heat transfer to the surroundings of the riser. In a riser, the outer sheath may overheat. By way of example, a riser outer sheath consisting of a polyamide called PA-11 is preferably kept below a temperature of 60°C, while an outer sheath made of TPflex needs to be kept below a temperature of 90°C. When power cables are used, there is a risk of the core overheating. The inventors have realised
10 that temperature control can be improved by creating a channel for air or fluid alongside the riser within the sleeve of the bending stiffener. A mount is also provided with an outlet which communicates with the channel.

15 Although the description refers to the use of bending stiffeners and spacers with risers, the spacers or bending stiffeners described herein can also be used for cables, umbilicals, pipelines or the like without substantial modification besides the dimensions.

20 The channel may be formed by modifying the inner surface of the bore of a bending stiffener. One or more channels are formed within the inner surface and extend along the length of the bending stiffener to allow convection flow between the ends of the stiffener. The attachment of the stiffener to the platform leaves one or more openings which are connected to the channels such that the flow exits the channels. The inventors have realised that a possible problem with channels provided within the inner
25 surface is a reduced strength of the bending stiffener. The reduced strength may cause buckling of the bending stiffener under a load.

30 In an embodiment, the channel is formed by using a conventional bending stiffener, but selecting a bending stiffener with an inner bore which is larger than the outer diameter of the riser. An annulus will therefore be created between the bending stiffener and the riser. Spacers are provided to maintain a fixed separation between the riser and the bending stiffener. Spacers also distribute a load evenly around the circumference. Even without the use of spacers there will be a gap between the riser and the bending stiffener, also when the riser is bent and in contact with the bending stiffener at various

parts of the bending stiffener. However, the points of contact may cause overheating and the use of spacers is therefore preferable.

5 A spacer can be formed of a plurality of longitudinal ribs extending along the longitudinal direction of the riser over at least part of the length of the bending stiffener. Each spacer can have an 'H-profile' or an 'I-profile', wherein the central part of the spacer extends in radial direction of the riser, while the end portions rest against the outer wall of the riser and the inner wall of the bending stiffener. Preferably, at least 8
10 spacers are provided around the circumference of the annulus to distribute the load, although a larger or smaller number may also suffice.

Alternatively, a spacer can be formed by a plurality of tubes extending along the longitudinal direction of the riser over part or all of the length of the bending stiffener. The ribs or tubes need to be made of a material which is sufficiently rigid to maintain
15 the channel under bending stress, while being sufficiently flexible to allow bending. The flexibility of the material is selected depending on the flexibility of the bending stiffener.

Preferably, a metal such as steel or aluminium is used for the spacer. A metal has the advantages of good heat transfer and high load bearing capacity. However, a
20 disadvantage is the high bending stiffness. In order to avoid the spacer limiting the bending of the bending stiffener, a plurality of spacer sections can be used in the longitudinal direction with gaps between the spacer sections to allow sufficient bending of the bending stiffener and to avoid metal fatigue due to bending.

25 Figure 1 illustrates a specific embodiment. A riser 1 extends downwards to a well from a platform 2 of a production facility. The riser is rigidly attached to the platform via a mount 3 and a plurality of fittings 4. The mount 3 includes an air (or fluid) outlet 5 which allows hot air to flow out of the mount and upwards through convection. A bending stiffener 6 is attached to the mount and extends downwards from the platform
30 and is fit around the riser. As illustrated in Fig. 1, the wall of the bending stiffener tapers down and thereby becomes thinner towards the lower part of the bending stiffener. As a result of the thinning of the wall the flexibility increases towards the thin end. The gradual change in flexibility will cause a gradual bending of the riser when the riser is under strain, with the fixed end of the riser substantially remaining straight
35 such that strain is minimised at the connection point between the riser and the facility.

The bender stiffener 6 defines an inner annulus 7 between the riser 1 arranged within the bending stiffener and the bending stiffener. The annulus provides a channel for air cooling through convection of heat. Arrow 8 illustrates inflow of cold air at the lower end of the annulus, while arrow 9 illustrates the outflow of hot air at the upper end of the annulus and through outlet 5.

The bending stiffener itself may be a conventional product, but with a bore diameter selected to be larger than the outer diameter of the riser (or cable) to create the annulus.

Although the singular word 'channel' is used in the description of Figure 1, the channel may include a plurality of smaller channels as described in more detail below with reference to Figure 3. Spacers are provided within the annulus 7, but are not illustrated in Fig. 1. Further detail is shown in Fi. 3.

Figure 2 illustrates an embodiment with an additional feature when compared to the embodiment of Figure 1. The features described in relation to Figure 1 are also part of the embodiment illustrated in Fig. 2 and are indicated with the same reference numbers in Fig. 2. In addition, a chimney (or air channel) 21 is communicatively coupled to the upper end of the annulus and extends upwards through platform 2. Arrow 22 at the top of chimney 21 illustrates hot air leaving the chimney. The chimney avoids hot air accumulating below the platform 2 and improves cooling by convection of air.

Figure 3 illustrates a plurality of spacers 31 used to maintain a constant separation between the riser and the bending stiffener. Figure 3 is a horizontal cross section through a riser 1 and bending stiffener 6. A plurality of spacers 31 (not all numbered) are distributed around the circumference of the annulus. Fig. 3a illustrates a horizontal cross section through one of the spacers. The shape of the spacer in the horizontal plane deviates slightly from a rectangle, either due to the pressure of the fit within the annulus or due to a preformed shape whereby the walls of the spacer which are in contact with the walls of the riser or bending stiffener are semi-circular with matching radius.

Figure 3b is a side view of a spacer element in the vertical plane. The side view is in a direction A illustrated in Figs. 3 and 3a, and is perpendicular to the radial direction. An opening 32 is provided through the sides of the spacer element and a wire 33 is fit through the openings and around the circumference of the annulus to keep the spacer elements in place. The top and the bottom of the side walls in the side view of Fig. 3b include a recess 34. The recess improves the flexibility of the spacer element.

Figure 3c illustrates a side view of a vertical plane in radial direction B. The side view shows that the ring of wire 33 with spacer elements 31 is replicated multiple times along the longitudinal direction. Gaps 35 are provided between the spacer elements to allow bending of the riser. Airflow is indicated with arrow C through the channels formed by the plurality of those spacer elements 31 which are positioned relative to each other with coinciding longitudinal axes.

Other spacers than those illustrated in Fig. 3 can be used. For example, corrugated metal sheets can provide the combination of spacing and airflow channels, or other structures with a zig-zag shape can be used. The spacers are distributed evenly around the circumference.

An additional optional feature is an airpump or fluid pump. The pump is preferably positioned on the platform and can be used to pump cooling air or cooling fluid through the channel or channels within the annulus. An advantage of an air pump, such as a fan, is that a narrower annulus can be used, but an air pump will increase complexity and costs. A passive system without an air pump requires a wider annulus for the chimney effect to work well. Air cooling is preferable over cooling with liquids because the air density depends more strongly on temperature and therefore creates better convection flow than liquids. When using liquid cooling, a closed cooling system with a pump is preferably used to ensure good cooling and to avoid pollution of the system by organisms which may be present in seawater.

Figure 4 is a graph showing the results of numerical simulations for the illustrated embodiments. The horizontal axis is the thickness of the annulus (called cooling layer in Fig. 4) in mm, and the vertical axis is the heat drain in W/m. An increase of the thickness corresponds to an increase of the heat drain. Two relationships are plotted:

one with a chimney and one without a chimney, and the use of a chimney further improves the heat drain.

5 Figure 5 illustrates a method comprising the steps of arranging a spacer as described above around an elongate member (S1) such as a riser and then placing a bending stiffener around the spacer (S2). The bending stiffener may be a conventional device.

10 Although the invention has been described in terms of preferred embodiments as set forth above, it should be understood that these embodiments are illustrative only and that the claims are not limited to those embodiments. Those skilled in the art will be able to make modifications and alternatives in view of the disclosure which are contemplated as falling within the scope of the appended claims. Each feature disclosed or illustrated in the present specification may be incorporated in the invention, whether alone or in any appropriate combination with any other feature
15 disclosed or illustrated herein.

CLAIMS:

1. An apparatus comprising:

a sleeve defining a bore, wherein a first end portion of the sleeve has a bending stiffness which is larger than the bending stiffness of a second end portion of the sleeve, wherein the bore receives in use an elongate member;

a mount connected to a first end of the sleeve, wherein the mount defines an outlet for air or fluids;

at least one channel for air or fluid provided along an inside surface of the sleeve,

wherein the channel is communicatively connected to the outlet, wherein the channel is defined by a spacer provided within the bore between the elongate member and the sleeve, the spacer comprising a plurality of spacing elements distributed at a plurality of locations around the inner circumference of the bore, and wherein the spacer defines said channel in the longitudinal direction of the sleeve.

2. The apparatus according to claim 1, wherein the air channel is connected to the air outlet.

3. The apparatus according to claim 1, wherein the spacing elements are tubular members with their longitudinal axis arranged in the longitudinal direction of the sleeve.

4. The apparatus according to any one of the preceding claims, wherein a plurality of tubular members are arranged in a longitudinal direction and wherein the plurality of tubular members are spaced apart from each other in the longitudinal direction.

5. The apparatus according to claim 4, wherein the radial cross section of at least one of the tubular members is circular or rectangular.

6. The apparatus according any one of the preceding claims, wherein the spacing elements are connected to each other by a wire extending in the circumferential direction of the annulus.

7. The apparatus according to any one of the preceding claims, wherein the elongate member is a riser, a flowline, a cable or an umbilical.

5 8. The apparatus according to any one of the preceding claims, further comprising a longitudinal air channel extending upwards from the outlet.

9. The apparatus according to any one of the preceding claims, further comprising a pump communicatively coupled to the channel.

10 10. A spacer for use between a bending stiffener and an elongate member, the spacer comprising:

a plurality of spacing elements distributed in a tubular arrangement, and wherein the spacer defines a plurality of channels for air or liquids in the longitudinal direction of the tubular arrangement.

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11. The spacer of claim 10, wherein the spacing elements comprise a plurality of tubular members, wherein the tubular members are arranged in said tubular arrangement and are connected by a wire in said tubular arrangement, and wherein the longitudinal axis of the tubular members is parallel to the longitudinal direction of the tubular arrangement.

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12. A method of assembling a spacer around an elongate member, the method comprising:

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placing a spacer around the circumference of an elongate member, wherein the spacer defines a plurality of channels along the longitudinal direction of the elongate member,

placing a bending stiffener around the spacer.

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13. The method of claim 12, wherein the spacer is the spacer as defined in claim 10 or 11.

14. The method of claim 13, further comprising securing the tubular members around the elongate member by arranging said wire through openings in the tubular members.

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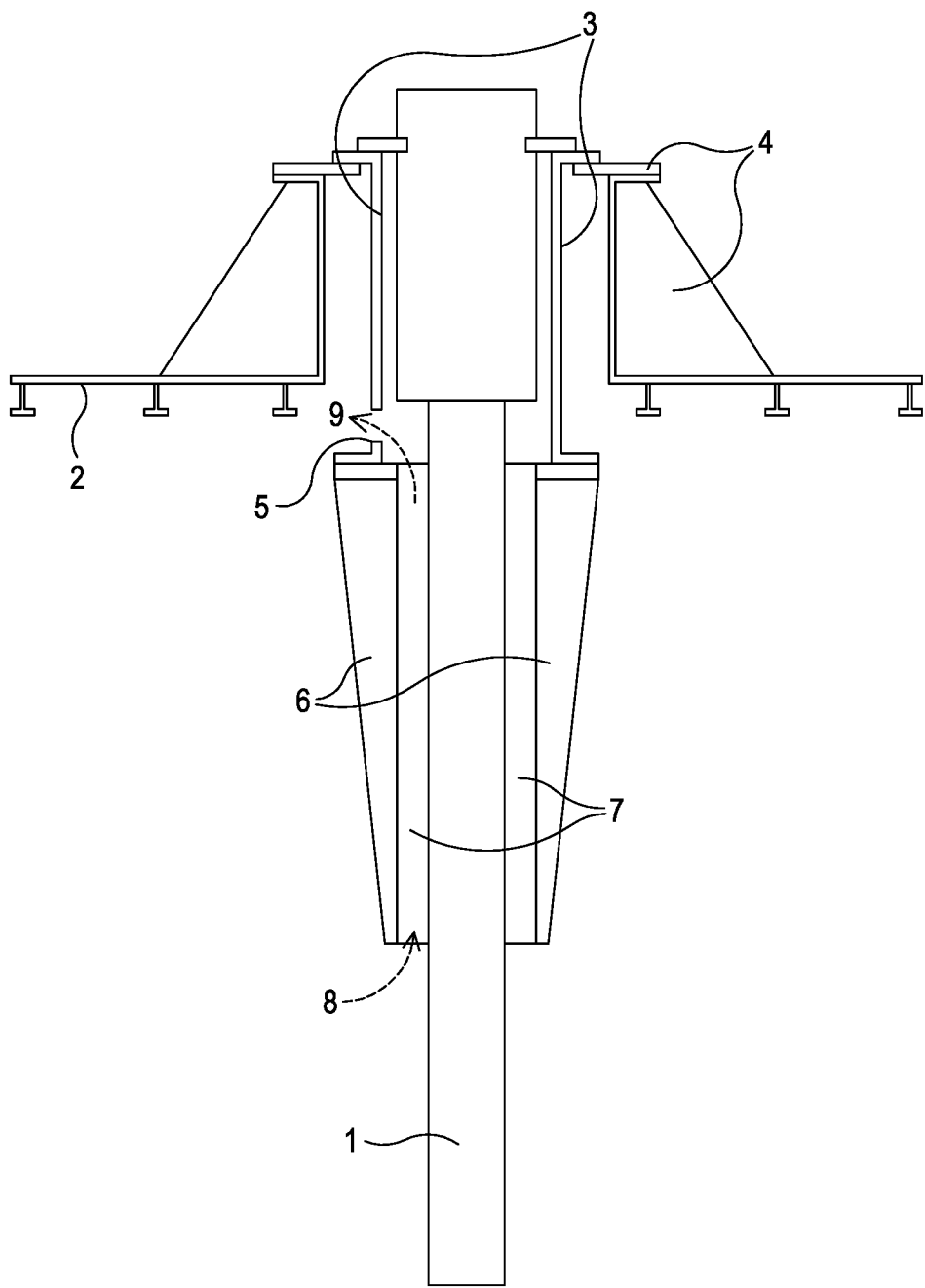


Fig. 1

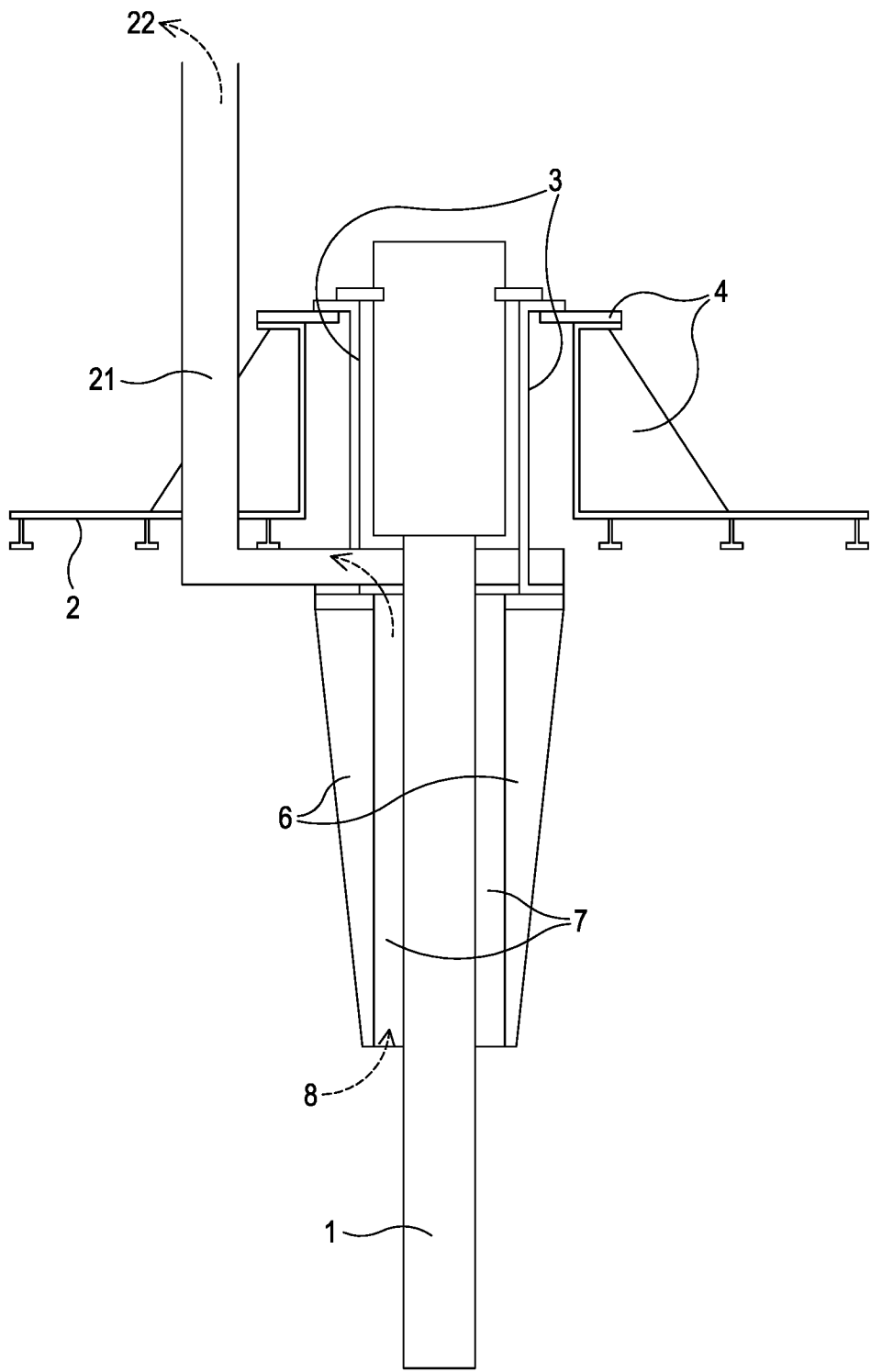


Fig. 2

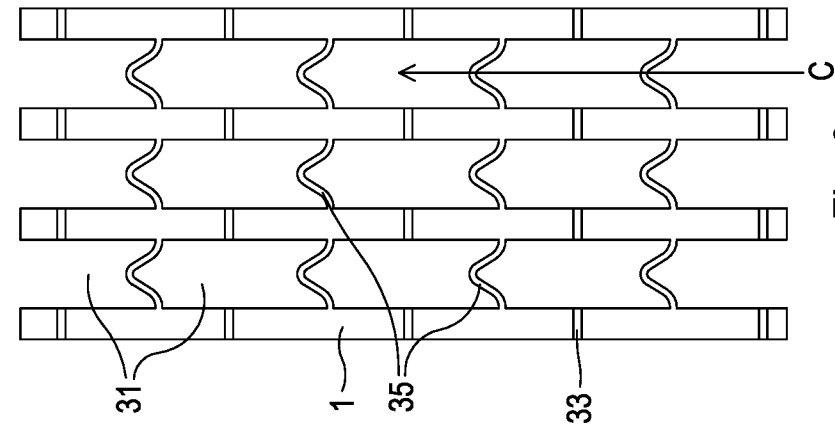


Fig. 3c

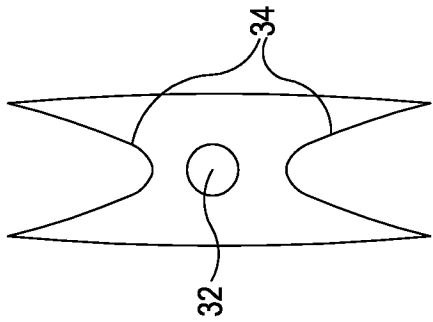


Fig. 3b

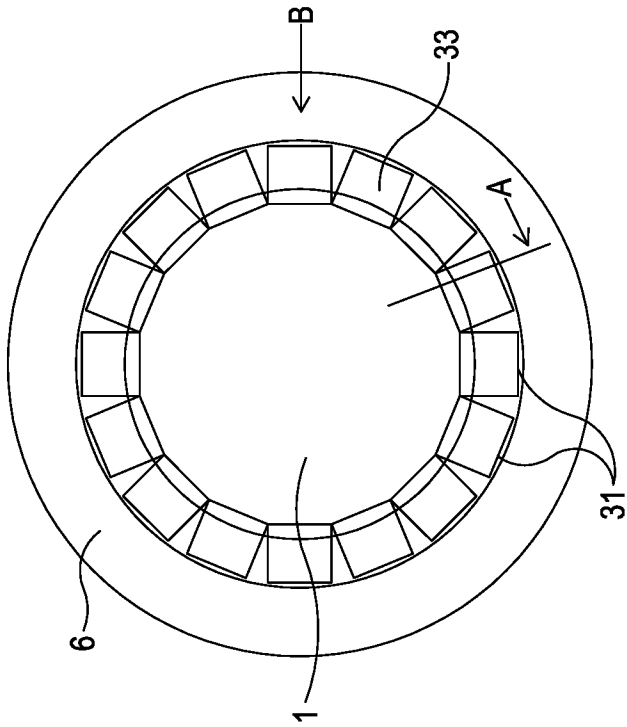


Fig. 3

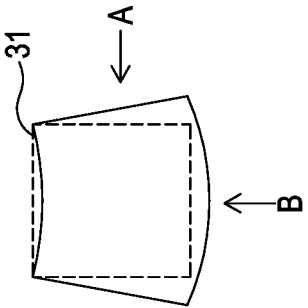


Fig. 3a

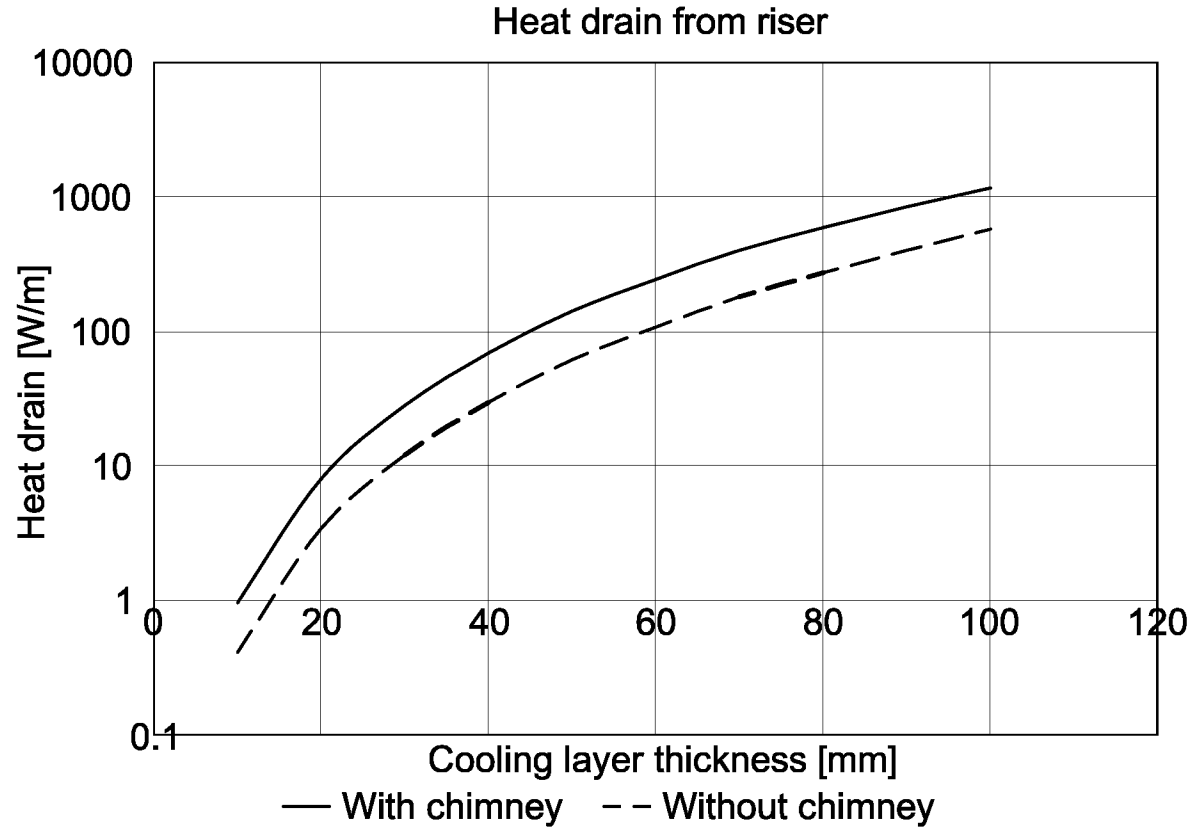


Fig. 4

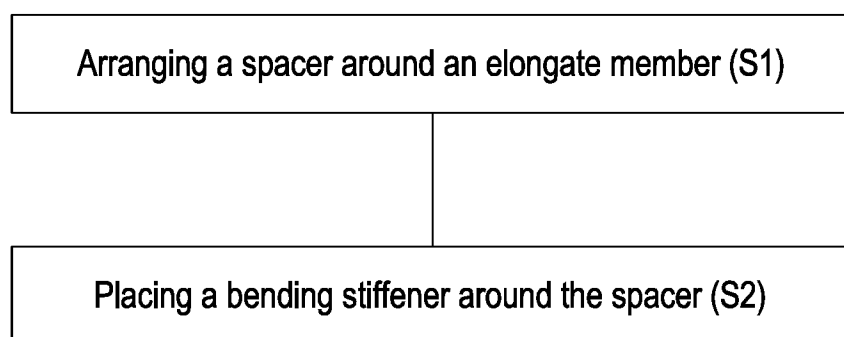


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.

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A. CLASSIFICATION OF SUBJECT MATTER		
E21B 17/01 (2006.01), E21B 36/00 (2006.01)		
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) E21B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched DK, NO, SE, FI: Classes as above.		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPODOC, WPI, FULL TEXT: ENGELISH, GERMAN, FRENCH		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009/0151789 A1 (SHELDRAKE, T. H.) 2009.06.18 Whole document, especially paragraphs [0040]-[0044]; figs. 3 and 4; claims 1-7.	1-14
A	US 6009907 A1 (SECHER, P.) 2000.01.04 Whole document, especially fig. 4; col. 8, lines 5-25.	1-14
A	US10094177 B2 (BJOERNEKLETT, B. et al.) 2018.10.09 Whole document, especially figs. 5-6; col. 6, lines 21-50.	1-14
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
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INTERNATIONAL SEARCH REPORT
Information on patent family members

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