

SPECIFICATION

Improvements in and relating to anchorage devices

The invention relates to an anchorage device particularly but not exclusively for anchoring a floating apparatus above a region which has a high density of immersed pipelines or, in general terms, above a region where anchorage by means of dead weights or conventional anchors may risk damaging pipelines or underwater installations.

Surface apparatus capable of maintaining their surface position without anchorage on the bottom of the sea are known, the apparatus being maintained in position by the dynamic action of suitably orientated motors. However, this type of apparatus is unsuitable for shallow water where it is necessary to resort either to fixed and permanent anchorages, situated vertically below the apparatus, for example stakes driven into the sea bed or simple dead weight bodies, or to conventional anchors placed relatively far away from the apparatus.

In the first case, anchoring is expensive and the closer the pipelines and installations to be safeguarded, the more delicate is the anchoring operation. This technique becomes prohibitively difficult when anchoring has to be effected at a plurality of points.

In the second case, anchoring takes place at points distant from the apparatus, and therefore, for raising the anchors, it is necessary to employ an auxiliary vessel which pulls up each anchor vertically from its anchoring point. This disadvantage limits its use in spite of the advantage which the method presents of being capable of sustaining, without excessive stresses, the pounding caused by the sea swell, because of the length of the anchoring cables. Conversely, the method of anchoring vertically below the apparatus has the disadvantage of subjecting the anchoring cables to high forces.

Thus, regardless of which conventional method is employed, the method does not lend itself well to rapid anchoring without the danger of damaging underwater pipelines and installations, and furthermore has the disadvantage of either necessitating an auxiliary vessel or of subjecting the anchoring cables to fatigue in the case of pounding or drifting.

According to the present invention there is provided an anchorage device comprising a dead-weight body to be suspended from an anchorage cable, said dead-weight body being deformable and comprising a flexible envelope only partly filled with particulate material.

The deformable body may comprise a flexible envelope partly filled with shot or any suitable heavy material consisting of elementary bodies or particles in sufficient number and of a suitable particle size to allow their relative movement so as to impart the desired deformability or plasticity to the body.

It is thus possible to produce, by suitable partial filling of the envelope, a body of sufficient

plasticity to ensure that simply lowering the body on to a pipeline causes its gradual deformation until the initial contact, which is effectively a point contact, of the body on the pipe is transformed into partial or complete straddling of the pipe by the body. The lower surface of the body then matches the outline of the sea bottom with the pipe.

The envelope may be reinforced between two given levels so that when the body rests on the bottom it can, without fatigue, withstand the lateral pressures exerted on it by the material in the envelope.

The appropriate partial filling of such an envelope in particular has the effect of not only permitting efficient and rapid anchoring without danger of damage of the underwater pipelines, but also makes it possible, in the case of any tendency of the apparatus to move away from its anchoring position, to increase gradually the tension on the cable by increasing the weight of the suspended portion of the body, thus increasing, at the same time, the lateral reaction exerted by the water due to the shift and which increases with increasing depth of immersion of the apparatus.

Thus, as in the case of anchorage by simple dead weight or by driven in stakes, anchorage vertically below the apparatus is utilised to create reaction forces which tend to return the apparatus to its initial position, but at the same time fatigue of the cables by the increase in force due to the partial raising of the body is avoided, since the body collapses again completely after the disturbing force has ceased. In this way, the advantages of the two conventional methods of anchorage are combined whilst eliminating the disadvantages inherent in one or other method.

To considerably reduce and even ultimately virtually eliminate the effects of the weight of the body applied directly to the pipeline or installation part, in a modification, the envelope of the anchorage device may be made watertight and a shut-off device provided at the upper end of the envelope, the shut-off device being dependent on an isolating valve having two positions, an open and a closed position, the valve being remotely controlled from the surface. The envelope is advantageously substantially completely filled with particulate material, which may be sand, round pebbles or any similar particulate material, when lying in position on the sea bed.

The envelope may have a generally conical shape, with the base either flat or domed, for example hemi-spherical. Preferably the maximum diameter of the envelope in the suspended position does not exceed the maximum external diameter of a protective device for protecting the upper and lateral parts of the body.

In use of an anchorage device as described above, the body is lowered onto the sea bed with the isolating valve in the open position. The body flattens gradually, the amount of material contained in the envelope having been chosen so that once the envelope is flattened, it is substantially completely filled with the material. It

then suffices to exert a slight pressure at the centre of the body to drive out any excess water which it had previously been able to contain. The weight of the isolating valve and its fixing means on the flexible envelope are sufficient for this purpose. The fixing means can advantageously be supplemented by a pressure-distributing plate which is interposed between the fixing means and the envelope. The valve is then shut, whereby the material inside the envelope is "frozen" into position, so that the body is converted to an effectively rigid disc, the lower face of which retains in tact the outline of the sea bed, especially the outline of any pipeline on which the body has been lowered. The anchorage device body thus rigidified can be re-lowered, slowly, onto its previous seat and it can thus be seen that it virtually no longer exerts any force on the pipeline, because its entire weight, including that of the material above the pipeline, rests on and is supported by the sea bed.

The above described body, comprising a flexible waterproof envelope may be further modified and comprise a second waterproof envelope at least in part surrounding the first envelope, which second envelope is also flexible and is connected to the first envelope in a leak type manner, at least along a horizontal diametral line common to both envelopes, the space between the two envelopes forming a leak proof chamber with flexible walls. The second envelope may for example be supported by the protective device.

Preferably the anchorage device includes a filling valve connected to the leak proof chamber between the envelopes and through which an appropriate fluid, for example water, can be introduced into the chamber.

This second envelope may be provided when all that is desired is, by virtue of the mobility of the fluid trapped between the two envelopes, to achieve better envelopment of an immersed pipeline or of part of an existing installation, on which the anchorage device must be placed, thereby contributing to lightening the load thereon, without necessitating the manoeuvre previously described.

There are however cases where this latter manoeuvre is particularly advantageous, especially where, after having positioned the anchorage device, it is necessary to exert an oblique force on it. The rigidified anchorage device body does not slide over the obstacle and hence does not exert any detrimental force thereon.

One or other of the modifications described above is all the more of interest because the weight of the body of the anchorage device can be as much as 40 tonnes.

The double-envelope anchorage device has the additional advantage that it reduces, to a not insignificant degree, the stress to which each part of the surface of the internal envelope is subjected, by comparison with the stress to which the same part would be subjected in the absence of the second envelope.

The leak-proof chamber defined between the

two envelopes may be divided into a plurality of leak-tight cells by means of internal partitions which are also flexible and impermeable and are connected in a leak-tight manner both relative to one another and to the two envelopes.

Each cell may be provided with a filling valve and may be filled with a liquid, e.g. water.

Such partitioning has the result of further reducing the unit stress exerted on the walls of the chamber. It also produces a reduction in the unit stress applied to a pipe or other body on which the anchorage device has been placed. It also results in better protection of the covering of the pipe or other body. The partitioning furthermore prevents high-amplitude movements of the fluid inside the leak-proof chamber.

The invention will be more fully understood from the following description of embodiments thereof, given by way of example only, with reference to the accompanying drawings.

In the drawings:

Figure 1 schematically represents a platform provided with an embodiment of an anchorage device according to the present invention, in its stored position on board;

Figure 2 is an enlarged view of the anchorage device of Figure 1 in its stored position;

Figure 3 is a schematic representation of the anchorage device of Figure 1 when in use resting on underwater pipelines;

Figure 4 is a schematic vertical section through another embodiment of an anchorage device according to the present invention, placed on the sea bed;

Figure 5 is a vertical section through a further embodiment of an anchorage device according to the invention, shown suspended; and

Figure 6 shows, very schematically, the different shapes which the bases of the anchorage devices of Figures 1 and 5 can assume after they have been placed on the sea bed.

Figure 1 shows schematically a surface apparatus 1, which may, for example, be a semi-submersible barge of which the cylindrical pillars 2, which connect the immersed caissons 3 to the platform 4, provide a stability of the apparatus. The apparatus 1 may be of any type and may be provided with longitudinal propelling devices 9. The apparatus 1 is provided with anchorage devices each of which includes a deformable body 6 having a spheroidal lower part and a conical upper part.

The apparatus 1 is provided with a support 5 in respect of each anchorage device, the support 5 maintaining the body 6 of the anchorage device spaced from the caisson 3 when the device is in its stored position. The body 6 of each anchorage device is suspended by a cable 7 controlled by a winch 8. The end of such support 5 is supported by a bracket 10 (Figure 2) and serves as a support for a bearing 11 of a pulley 12 which rotates about an axis 13 while guiding the cable 7 when the anchorage device is being lowered or raised.

An attachment 14 located at the end of the cable

7 engages a protective device 15 which fits over and protects the upper and lateral parts of the body 6.

The body 6 comprises an envelope 16 consisting of a metal fabric or net, which envelope is filled with a particulate material. The envelope 16 may be reinforced in its middle zone 17, which zone in the present embodiment has the largest horizontal diameter, to withstand the forces exerted on it by the material which it holds. In this way it is possible, as shown in Figure 3, to avoid excessive lateral deformations in spite of the deformability or plasticity of the body 6 and of its filling, which can weigh several tens of tonnes. Figure 3 shows an anchorage device which has been lowered onto two pipelines 18 and 19 resting on the sea bed 20. As shown the pipelines are only subjected to a fraction of the weight of the body 6, the sea bed adsorbing the greater part of the weight. Furthermore, even where the body straddles the pipeline completely, the relatively large contact area of the pipelines 18 and 19 with a very small fraction of the body, even when it is suspended from the cable 7 and not resting on the sea bed, avoids deformation of these pipelines.

When the cable 7 is raised again, the body reassumes the shape shown in Figure 2, and the protective device 15 avoids any friction between the envelope 16 and the caissons 3. The device may be equipped with means of orientation of the pulley about the axis 21 of the bearing 11, and, it will be appreciated that the support 5 can be replaced by another suitable support system.

Partial filling of the envelope allows considerable deformation of its lower part, as can be seen in Figure 3.

When, for example due to the action of wind, the surface apparatus 1 shifts, at least one of the cables 7 becomes tensioned, and gradually raises its body 6. During this operation, the contact area of the body with the sea bed decreases so that the weight supported by the cable constantly increases and the contact area on the seabed decreases. The tendency of the apparatus to sink causes a reaction of the water, in the opposite direction to the direction of movement of the apparatus, thus returning the latter to its original position. The weight of the supported part of the body thus again diminishes. Thus, contrary to the usual dead weights, the anchorage cable 7 no longer undergoes abruptly increasing forces during the shift of the apparatus or during its buffeting, the force on the cable increasing gradually by variation in the weight which it supports.

Furthermore the body of the anchorage device can be set down very rapidly regardless of the anchorage position, and any pipelines on which it is set down should not be damaged because of the deformability or plasticity of the body, the gradual variation in the weight applied to the sea bed and the relatively large contact area between the pipeline and the body when the body reaches its final lowered position.

The envelope of the body can be laterally

reinforced by suitable flexible or even elastic material and the filling material can, for example, be any suitable particulate material for example metal shot or mineral particles. The metal net envelope may be combined with, or replaced by, a flexible envelope. Equally the body can have another shape than that shown in Figure 2. Not only need the lower part of the body not be spheroidal, but the upper part itself need not be conical. The less the envelope is filled with particulate material, the more inelastically deformable is the body.

Figure 4 shows a modification of the embodiment described above which comprises a body 61 having a waterproof envelope 161. The size of the envelope 161 and the amount of particulate material which it contains are selected so that, in the flattened condition of the body, it assumes the shape of a circular slab, of diameter substantially greater than that of the protective device 15. As shown, the body has been placed over an immersed pipeline 18 on the sea bed 20, the pipeline 18 producing its imprint at 211 in the undersurface of the envelope.

A pipeline 221 is connected to the interior of the envelope and passes through a shut-off device 231 which is dependent on a valve 241, which is remotely controlled from a station shown schematically at 251.

A plate 261 which distributes the weight of the control devices and protection devices is interposed between these and the envelope 161.

The whole is suspended from the cable 7 by means of an attachment means 14.

The above described anchorage device is used as hereinbefore described so that when the body is in position on the sea bed it can be "frozen" and converted into an effectively rigid disc.

Figure 5 shows a further modification which comprises a first or inner waterproof envelope 161 and a second waterproof envelope 271 which surrounds, over at least a part of its surface, the first envelope, the two envelopes 161, 271 being connected together along a diametral horizontal line 281 which is common to both envelopes. As before, a protective device 15 is provided. The inner envelope 161 is fixed at its apex 291 to the apex of the protective device 15, which is itself suspended from the cable 7. The outer envelope 271 is fixed to the protective device 15 along a common diameter 301, at the toroidal part of device 15, which constitutes the base of the device 15, the diameter 301 intersecting the plane of the figure at 311. The space between the two envelopes is divided into a plurality of leak-tight cells 321 by flexible partitions 331. Each cell is provided with a filling valve (not shown) to enable each cell to be filled with a liquid, for example water.

The anchorage device of this embodiment need not be provided with a remotely controlled valve and is, in general, used in preference to an anchorage device as described with reference to figures 1 to 3 where better envelopment of an immersed pipeline or part of an existing

installation is required.

In Figure 6 an immersed pipeline 18 placed on the sea bed 20 is shown. The broken line 341 represents the cross-section of the envelope of an anchorage device as shown in Figures 1 to 3. The solid line 351 represents the cross-section of the second or outer envelope of an anchorage device as shown in Figure 5, the internal envelope of the device being shown at 361. Figure 6 shows clearly that the anchorage device of Figure 5 matches the periphery of the pipeline 18 more closely than the device of Figures 1 to 3, by virtue of the provision of the second envelope.

The shape of the inner envelope of the anchorage device of Figure 5 may be substantially conical in its upper part with a flat or domed, for example hemi-spherical, base.

There is thus provided a means of anchorage by simply lowering a deformable body suspended from a cable onto the sea bed, the body being capable of resting on pipelines without damaging them and without exerting local stresses or unacceptable pressures, because of the relatively large contact area of the body, by virtue of its deformation, on the pipeline.

It will be appreciated that the present invention is not intended to be limited to the embodiments which have been described above, and that modifications in detail can be made thereto without departing from the scope of the invention as defined by the appendant claims.

CLAIMS

1. An anchorage device comprising a dead-weight body to be suspended from an anchorage cable, said dead-weight body being deformable and comprising a flexible envelope only partly filled with particulate material.

2. A device as claimed in claim 1, wherein the middle part of said envelope is reinforced to resist the pressure of said material.

3. A device as claimed in either claim 1 or claim 2, wherein said envelope of said body is made of metal net.

4. A device as claimed in any one of claims 1 to 3, wherein the upper part of said deformable body when suspended from said cable is of substantially conical shape.

5. A device as claimed in any one of claims 1 to 4, wherein the lower part of said deformable body, when suspended from said cable, is spheroidal.

6. A device as claimed in any one of claims 1 to 4, wherein the lower part of said deformable body, when suspended from said cable, is substantially hemispherical.

7. A device as claimed in any one of claims 1 to 4, wherein said body, when suspended from said cable, has a substantially flat base.

8. A device as claimed in any one of claims 4 to 7 when dependant on either claim 1 or claim 2,

60 wherein said envelope is impermeable.

9. A device as claimed in claim 8, including a shut-off device connected to the interior of an upper part of said envelope and dependant on a remotely controlled valve having two positions being an open position and a closed position.

10. A device as claimed in any one of claims 1 to 9 including a protective device for protecting the upper and lateral parts of said body.

11. A device as claimed in claim 10, wherein when said body rests on a surface, it assumes the shape of a flattened disc of diameter greater than that of said protective device.

12. A device as claimed in claim 11, including a pressure-distributing plate interposed between said protective device and said body.

13. A device as claimed in claim 8, including a second envelope which is flexible and impermeable, said second envelope at least in part surrounding said first envelope.

14. A device as claimed in claim 13, wherein said first and second envelopes are assembled together in a leak-proof manner at least along a diametral horizontal line, to both of said envelopes, the space between said envelopes forming a leak-proof chamber with flexible walls.

15. A device as claimed in either claim 13 or claim 14, wherein said second envelope is supported by said protective device.

16. A device as claimed in either claim 14 or claim 15, including a filling valve connected to said leak-proof chamber.

17. A device as claimed in any one of claims 14 to 16, wherein said leak-proof chamber is completely filled with fluid.

18. A device as claimed in any one of claims 14 to 17, including internal partitions made of flexible and impermeable material and dividing said leak-proof chamber into a plurality of leak-tight cells.

19. A device as claimed in claim 18, including a filling valve in respect of and connected to each respective cell.

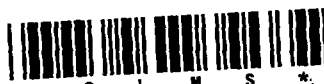
20. A device as claimed in either claim 18 or claim 19, wherein each said cell is completely filled with a fluid.

21. An anchorage device substantially as herein described with reference to Figures 1 to 3 of the accompanying drawings.

22. An anchorage device substantially as herein described with reference to Figure 4 of the accompanying drawings.

23. An anchorage device substantially as herein described with reference to Figure 5 of the accompanying drawings.

24. An anchorage assembly for anchoring a surface apparatus comprising a plurality of anchorage devices as claimed in any one of the preceding claims, each suspended from a cable, and a guide device in respect of each cable for ensuring that the respective said body of said



installation is required.

In Figure 6 an immersed pipeline 18 placed on the sea bed 20 is shown. The broken line 341 represents the cross-section of the envelope of an anchorage device as shown in Figures 1 to 3. The solid line 351 represents the cross-section of the second or outer envelope of an anchorage device as shown in Figure 5, the internal envelope of the device being shown at 361. Figure 6 shows clearly that the anchorage device of Figure 5 matches the periphery of the pipeline 18 more closely than the device of Figures 1 to 3, by virtue of the provision of the second envelope.

The shape of the inner envelope of the anchorage device of Figure 5 may be substantially conical in its upper part with a flat or domed, for example hemi-spherical, base.

There is thus provided a means of anchorage by simply lowering a deformable body suspended from a cable onto the sea bed, the body being capable of resting on pipelines without damaging them and without exerting local stresses or unacceptable pressures, because of the relatively large contact area of the body, by virtue of its deformation, on the pipeline.

It will be appreciated that the present invention is not intended to be limited to the embodiments which have been described above, and that modifications in detail can be made thereto without departing from the scope of the invention as defined by the appendant claims.

CLAIMS

1. An anchorage device comprising a dead-weight body to be suspended from an anchorage cable, said dead-weight body being deformable and comprising a flexible envelope only partly filled with particulate material.

2. A device as claimed in claim 1, wherein the middle part of said envelope is reinforced to resist the pressure of said material.

3. A device as claimed in either claim 1 or claim 2, wherein said envelope of said body is made of metal net.

4. A device as claimed in any one of claims 1 to 3, wherein the upper part of said deformable body when suspended from said cable is of substantially conical shape.

5. A device as claimed in any one of claims 1 to 4, wherein the lower part of said deformable body, when suspended from said cable, is spheroidal.

6. A device as claimed in any one of claims 1 to 4, wherein the lower part of said deformable body, when suspended from said cable, is substantially hemispherical.

7. A device as claimed in any one of claims 1 to 4, wherein said body, when suspended from said cable, has a substantially flat base.

8. A device as claimed in any one of claims 4 to 7 when dependant on either claim 1 or claim 2,

wherein said envelope is impermeable.

9. A device as claimed in claim 8, including a shut-off device connected to the interior of an upper part of said envelope and dependant on a remotely controlled valve having two positions being an open position and a closed position.

10. A device as claimed in any one of claims 1 to 9 including a protective device for protecting the upper and lateral parts of said body.

11. A device as claimed in claim 10, wherein when said body rests on a surface, it assumes the shape of a flattened disc of diameter greater than that of said protective device.

12. A device as claimed in claim 11, including a pressure-distributing plate interposed between said protective device and said body.

13. A device as claimed in claim 8, including a second envelope which is flexible and impermeable, said second envelope at least in part surrounding said first envelope.

14. A device as claimed in claim 13, wherein said first and second envelopes are assembled together in a leak-proof manner at least along a diametral horizontal line, to both of said envelopes, the space between said envelopes forming a leak-proof chamber with flexible walls.

15. A device as claimed in either claim 13 or claim 14, wherein said second envelope is supported by said protective device.

16. A device as claimed in either claim 14 or claim 15, including a filling valve connected to said leak-proof chamber.

17. A device as claimed in any one of claims 14 to 16, wherein said leak-proof chamber is completely filled with fluid.

18. A device as claimed in any one of claims 14 to 17, including internal partitions made of flexible and impermeable material and dividing said leak-proof chamber into a plurality of leak-tight cells.

19. A device as claimed in claim 18, including a filling valve in respect of and connected to each respective cell.

20. A device as claimed in either claim 18 or claim 19, wherein each said cell is completely filled with a fluid.

21. An anchorage device substantially as herein described with reference to Figures 1 to 3 of the accompanying drawings.

22. An anchorage device substantially as herein described with reference to Figure 4 of the accompanying drawings.

23. An anchorage device substantially as herein described with reference to Figure 5 of the accompanying drawings.

24. An anchorage assembly for anchoring a surface apparatus comprising a plurality of anchorage devices as claimed in any one of the preceding claims, each suspended from a cable, and a guide device in respect of each cable for ensuring that the respective said body of said



(17)

anchorage device is lowered and raised vertically
from the anchorage position.

25. An anchorage assembly substantially as

herein described with reference to the
5 accompanying drawing.

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