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(54) IMPROVEMENTS IN OR RELATING TO ANCHOR-CABLE SYSTEMS

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- (71) I, PETER BRUCE, of British Nationality, of 10, Torphichen Place, Edinburgh, EH3 8DU, Scotland, Great Britain, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—
- The present invention relates to an anchor-cable for mooring an object to a mooring bed, for example, for mooring a vessel or other floating body, or a standing or floating drilling rig or the like to the sea bed.
- The word "cable" as used hereinafter and in the claims includes wire hawser, chain cable and the like.
- By the term "vertical burial attitude" as used hereinafter and in the claims applied to a device designed to produce self-burying forces when being dragged through a mooring bed is meant that attitude of the device wherein the resultant burying force developed by the device when being dragged through a mooring bed tends to make the device follow a downwards trajectory contained substantially in a vertical plane:
- In previously proposed anchor-cable systems, the anchor includes a shank part to which are attached flukes which can be inclined relative to the shank such that, with the anchor on a sea bed of soft material such as for example mud, sand or gravel and with the shank horizontal and connected by an elongate cable to an object to be moored, the flukes dig into the sea bed when the anchor is subjected to a horizontal pull from the cable and so causes burial of the anchor.
- It has been found advantageous in previously proposed anchor-cable systems that the anchor be substantially buried to encourage the holding power of the overall system. However, with the previously proposed anchor-cable systems, with increasing depth of burial of the anchor, the buried portion of the cable gives rise to increasing uplifting forces being applied to the anchor and also tends to adopt an approximately catenoidal configuration,

resulting in pivoting of the anchor as a whole, whereby the angle of attack of the flukes relative to the horizontal is decreased, and the downwards force acting on the flukes to bury the anchor and cable is consequently also decreased when required to overcome the increasing uplifting force due to the cable. This change of attitude rapidly progresses until the angle of attack of the flukes is so reduced that an equilibrium state is established with the result that no further burial of the anchor and cable is possible.

The operation of a previously proposed anchor-cable system, currently in use, will now be examined to determine its limitations.

In an anchor of the previously proposed anchor-cable system, the maximum angle of attack of the flukes to the horizontal in a working attitude is the greatest angle enclosed by the plane of the flukes and a straight line passing through the intersection of the pivot axis of the cable shackle pin with the extremity of the shank remote from the flukes and passing through the centroid of the flukes.

In a working attitude of the anchor this maximum angle of attack of the flukes may be designated α and the abovementioned straight line referred to as the tangent to the cable at the shackle pin or, for brevity, the tangent.

With such an anchor on the sea bed with the flukes penetrating the surface of the bed and the portion of the cable adjacent the anchor being substantially horizontal, and for horizontal motion of the anchor, the forces developed by the anchor may be resolved into a vertically downward burying component, $P = a \text{ function of } \alpha = f(\alpha)$, and a horizontal drag component, $D = f(\alpha) + K$, where K is the horizontal component of anchor drag when the anchor orientation is such that the cross-sectional area in the direction of movement is at a minimum. In the above attitude, the tangent to the cable at the shackle pin is horizontal.

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the adjacent portion of cable, under the action of the horizontal pull imparted by the cable, the buried portion of the cable will tend to adopt a curve approximately catenoidal in form, due to distributed resistive forces acting along its length arising from movement through the resistive medium of the sea bed. The portion of the cable directly adjacent to the shackle pin on the shank of the anchor and, consequently, the tangent thereof will be inclined therefore to the horizontal by some angle β . The angle of attack of the anchor, α , thus will be reduced by the magnitude of the angle β as the anchor and cable penetrates below the sea bed surface so that now $P=f(\alpha-\beta)$ and $D=f(\alpha-\beta)+K$. Thus the forces developed by the anchor tend relatively to decrease with depth of burial due to a progressive decrease of the angle of attack of the flukes caused by the increasing curvature of the cable.

The resistive forces distributed along the buried portion of the cable may also be resolved vertically and horizontally and summed to give an upward lift component opposing the burial force, P , of the anchor and a horizontal drag component opposing the pull applied to the anchor cable above the sea bed surface.

When all the components of the forces developed by the buried portion of the cable and the anchor are added, the horizontal drag components may be seen to act together to constitute the horizontal holding power of the anchor-cable system while the vertical uplifting and burial components oppose and are equal in the equilibrium state.

As the depth of burial of the anchor increases, the overlying reaction volume of sea bed material increases and so the burial force deriving from this reaction volume tends also to increase. However, as the angle β increases, the angle of attack of the flukes decreases with the result that the rate of increase of burial force with increasing depth of burial is reduced to a rate less than the rate of increase of the upward lift component of force developed by the cable. The increasing upward lift component of force ultimately overtakes and equals the burial component of force developed by the anchor and so vertical equilibrium of the anchor cable system is established. In this equilibrium condition, the anchor has reached the maximum depth of penetration allowed by the cable and moves horizontally only. The horizontal holding force developed with the anchor just moving, comprising anchor drag and cable drag, is now a constant and is generally quoted as the maximum holding power of the anchor although a substantial portion of the holding power of such an anchor-cable system may be derived from the buried portion of the cable.

It is an object of the present invention to

provide an anchor-cable system of substantially increased holding power.

According to the present invention, a cable for attachment to an anchor for mooring an object to a mooring bed includes one or more spaced devices adjacent to the anchor end of the cable, at least one surface of each device being inclined relative to the cable axis and when said device is in a vertical burial attitude being inclined to the horizontal whereby, on penetration of the portion of the cable including the devices into the mooring bed when a substantially horizontal pull is applied to the anchor cable, the inclined surfaces of each device produce burial forces capable of burying the device and counteracting the vertical drag forces developed by the adjacent buried portion of the cable such that said portion is constrained to depart from an approximately catenoidal configuration and tend to adopt a substantially linear configuration or a curvature that is reverse to said catenoidal configuration.

Preferably the inclined surface of each cable-mounted device is a surface of an inclined fin forming part of the device.

Preferably the centre of area of the inclined fin of each device is offset from the axis of the cable.

Preferably at least three fifths of the total area of the inclined fin of each device lies at one side of the cable axis.

Preferably the fin-bearing portion of each finned device is pivotably mounted about the cable axis to permit the inclined fin to trail behind the cable and so adopt automatically an effective working orientation.

Preferably each cable-mounting device has two or more burial fins inclined relative to each other as well as to the cable axis such that the device is symmetrical about a vertical plane bisecting it when the device is in a vertical burial attitude, and such that the fins are in an anhedral configuration.

Preferably the disposition of the burial fin surfaces of each device is such that, when said device is interacting with the mooring bed surface in a reverse attitude to a vertical burial attitude, the resultant force vector produced by the portions of burial fin lying at either side of the vertical plane of symmetry bisecting the device, and making contact with the surface material of the mooring bed, lies on a straight line intersecting the vertical plane of symmetry at a point below the axis of the portion of the cable trailing behind the device.

Preferably a plurality of devices are mounted on the cable, the angles of inclination relative to the cable axis of the inclined surfaces of all of the devices being equal in magnitude to each other.

The angle of inclination of the inclined surface of the cable-mounting device to the axis of the cable may be at any angle whereby

sufficient burial force is developed by the device on engaging the mooring bed in the working vertical burial attitude to bury the device and counteract the resistance of a portion of the adjacent cable to penetration into the mooring bed.

Preferably the angle of inclination to the cable axis of the line of intersection of the inclined burial surfaces of each device with the plane of symmetry of each device is within the range 15° to 60°, and particularly 30° to 60°.

In a preferred embodiment of the invention, each fin-bearing device includes a forward clamping collar positionable on a wire hawser cable and having an annular recess on an end wall thereof, a sleeve on which are mounted a pair of offset opposed fins inclined relative to the axis of the collar and to each other and a third fin between the opposed fins and upstanding from the sleeve, the leading end of the sleeve being insertable into the recess of the forward collar whilst the trailing end of the sleeve is provided with a recess, and a trailing clamping collar insertable into the recess of the sleeve to locate the sleeve rotatably in position on the wire hawser cable.

Alternatively, these devices may be located on a chain cable whereby each fin device includes a forward fairing carrying a chain ring and having an annular recess on an end wall thereof, a sleeve on which are mounted a pair of offset opposed fins inclined relative to the axis of the fairing and to each other and a third fin between the opposed fins and upstanding from the sleeve, the leading end of the sleeve being locatable into the recess of the forward fairing and fitting pivotably about a rearwardly projecting cylindrical projection of the fairing which serves as a bearing for the sleeve. The trailing end of the sleeve is provided also with an annular recess into which a retaining collar may be fitted while encircling the rear end of the cylindrical projection of the forward fairing. A chain ring may be positioned at the rear of the projection and both retaining collar and chain ring secured to the projection, say, by welding.

The device may then be deployed as an integral link in the chain cable.

The opposed fins may be inclined nose down at an angle to the axis of the sleeve in the range of 15° to 60°, and particularly 30° to 60°.

Considering now the approximately catenoidal curve of the cable, it will be readily appreciated that the curve is the result of the drag forces distributed along the buried length of the cable and the burial force developed by the anchor located at the end of the cable.

By the devices according to the present invention, the cable is constrained to depart from the usual catenoidal curve and take up a substantially linear configuration of fixed

slope throughout its length buried below the sea bed surface. The tangent at the shank shackle pin of the anchor will have the same slope as the cable and will be colinear with it. The distributed spaced burial forces, due to the devices on the cable, can be arranged to enforce a known fixed slope on the linearised buried cable so that the angle β is never large enough to reduce substantially the angle of attack of the terminal anchor from the maximum. The anchor will thus continue to function effectively and produce a large burial force irrespective of the depth of penetration of the anchor and cable below the sea bed surface.

Furthermore, the finned devices mounted on the cable are each capable of producing a burial force equal to the lifting force developed by the portion of cable forming an interval between adjacent finned devices in addition to the burial force necessary to bury the finned device itself, so no increase of upward lifting force will be impressed on the terminal anchor due to increase of the buried length of the cable with increasing depth of burial of the anchor. Therefore, all the limitations to the depth of burial of an anchor and cable mooring system will be eliminated or substantially mitigated if finned devices of the present invention are distributed by spacing along the cable. The holding power of such an anchor and cable mooring system will depend only on the depth of anchor-penetrable soil beneath the sea bed surface provided that finned devices are mounted on a sufficient length of cable adjacent to the terminal anchor. Given an adequate depth of anchor-penetrable mooring bed, the holding power may be chosen to have a maximum as close to the breaking strength of the anchor cable as desired simply by mounting a sufficient number of finned devices on the cable to allow the terminal anchor to penetrate far enough under the sea bed surface.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings in which:

Fig. 1 shows a sectional side view of a fin device for a cable, according to a first embodiment of the present invention;

Fig. 2 shows an oblique underside view of the fin device of Fig. 1;

Fig. 3 shows a front view of the fin device of Fig. 1 looking in the direction of arrow A in Fig. 1;

Fig. 4 shows an oblique top view of the fin device of Fig. 1;

Fig. 5 shows a side view of a fin device according to a second embodiment of the present invention; and

Fig. 6 shows schematically the use of a conventional anchor cable system for mooring a ship; and the use of fin devices according to Figs. 1 or 5 on the cable of an anchor-

cable system. The increase in the angle of attack ($\alpha-\beta$) of the flukes of the anchor due to the use of the fin devices on the cable is shown.

5 By way of preliminary illustration, referring to Fig. 6, in a conventional anchor-cable system, an anchor 18 for mooring a vessel 2 to a soft sea bed 3 (for example, a sea bed of mud, sand, or gravel) is connected to the vessel by an elongate cable 19, the length of which is several times greater than the depth of water at the mooring location. Consequently, with the anchor 18 on the sea bed 3, the portion of the cable adjacent the anchor 18 is substantially horizontal. When a pull is imparted to the cable 19 due to movement of the vessel 2, the flukes of the anchor 18 will have a maximum angle of attack α relative to the sea bed 3. Horizontal movement in this attitude causes the flukes to bury the anchor and drag a portion 19A of the cable 19 below the sea bed surface. Penetration resistance forces distributed along the buried length of cable 19A cause it to adopt the catenoidal configuration shown. As deeper burial proceeds, the angle β of the tangent to the cable relative to horizontal at the anchor shackle increases until the angle of attack ($\alpha-\beta$) at the anchor fluke is so reduced as to preclude further burial of the anchor 18. The anchor 18 and cable 19A are now in equilibrium with the anchor 18 moving horizontally at a depth limit A which is dependent on the penetration resistance forces developed on the cable 19A.

Thus, the depth of burial of the anchor 18 and, hence, the holding pull of the conventional anchor-cable system is limited by the resistance to penetration of the cable as it is drawn below the surface of the sea bed.

Referring now to Figs. 1 to 6, according to an embodiment of the present invention, a cable 20 for attachment to an anchor 21 for mooring a ship to the sea bed has one or more spaced fin devices 22 adjacent to the anchor end thereof. The spacing H of the fin devices 22 may be at some suitable interval such that the burial force generated by each device 22 can bury the device 22 and, in addition, counteract the vertical drag resistance of an interval of cable 20 between adjacent devices 22. For use with wire cable (Figs. 1 to 4) each fin device 22 includes a rotatable sleeve 23 (Fig. 1) on the cable and a pair of collars 24, 25 one at each end 23A, 23B, of the sleeve 23 and locked to the cable 20, for locating the sleeve 23 on the cable 20. A pair of offset opposed fins 26 (Figs. 3 and 4) project from the sleeve, are inclined relative to each other (see Fig. 4) and also are inclined relative to the axis of the sleeve 23 such that, with the cable 20 positioned horizontally at the sea bed 3, the opposed offset fins 26 present an angle of attack to the sea bed 3 when the overall centre of area of the

fin 26 lies above the cable 20 in the vertical plane through the cable axis. The angle of inclination of the fins with respect to the cable axis is preferably within the range 15° to 60° ; but could be any angle whereby useful burial force sufficient to bury the fin device together with a portion of the adjacent cable is produced as the cable 20 moves through the sea bed soil. The leading collar 24 has an end wall 27 with an annular recess 28 therein, and the leading end of the sleeve 23A is inserted into this recess 28; and the other (trailing) end 23B of the sleeve 23 has a recess 29 into which the trailing collar 25 is inserted to position the sleeve 23 on the cable 20. A rearwardly projecting annular extension 30 of the leading collar 24 serves as a bearing for the sleeve 23. A further fin 31 is provided between the opposed fins 26 and projects normally from the sleeve 23. This third fin 31 is located in a plane containing the axis of the sleeve 23.

Referring to Fig. 5, for use with chain cable, each fin device 22 includes a rotatable sleeve 40 which has its forward end 40A located and supported in a forward fairing 41 furnished with a chain ring 42 and the trailing end 40B of the sleeve 40 accommodates the leading end of a trailing fairing 43. The fairings 41, 43 are linked with the chain and perform the function of a chain link. A pair of offset opposed fins 44 project from the sleeve 40, corresponding to the fins 26 of the Fig. 1 arrangement, and operate similarly. The forward fairing 41 has an end wall 45 with an annular recess (not shown) therein, and the leading end 40A of the sleeve 40 is inserted into this recess; and the other (trailing) end 40B of the sleeve 40 has a similar recess (not shown) into which a retaining collar may be fitted which collar encircles a rearwards projecting cylindrical projection of the forward fairing 41 which serves as a bearing for the sleeve. The aft chain ring 42 of the forward fairing 41 is welded to the rear of the rearwards projecting cylindrical projection of the forward fairing 41. As with the device 22 of Fig. 1 a further fin 46 is provided between the opposed fins 44 and projects normally from the sleeve 40 while located in a plane containing the axis of the sleeve 40.

The cable system is intended for use particularly in a soft sea bed of the type hereinbefore described.

In the operation of the anchor-cable system, say for mooring a ship 1 to a soft sea bed 3, the length of cable 20 used is several times the depth of water at the mooring location so that the portion 20A of the cable adjacent the anchor 21 normally lies substantially horizontal along the sea bed. The anchor used may be any anchor capable of penetrating and burying into the sea bed. When a pull is imparted to the cable 20 due

to the movement of the ship 1, the anchor 21 and the portion of the cable 20A adjacent thereto penetrate into the sea bed 3. Penetration of the sea bed surface by the cable 20 under the action of the terminal anchor 21 causes the fin devices 22 to engage the sea bed with the result that burial forces are developed at the inclined fins 26, 44 of the fin devices 22. These burial forces bury each fin device 22 and counteract the soil penetration resistance forces acting vertically on the cable between each fin device 22 so that the buried portion of the cable tends eventually to adopt a substantially linear configuration with the inclined fins 26, 44 of the fin devices 22 in parallel alignment and trailing behind the cable due to the action of the central fin 31, 46 and the offset disposition of the fins 26, 44.

It will be understood that the fin devices 22 will automatically establish the correct trailing aspect, on engaging the sea bed 3, owing to the separation of the centre of area of the fins 26, 44 from the axis of the cable and the disposition of the fins as a group.

Thus, the angle of inclination β of the anchor end of the cable to the horizontal, is maintained smaller than would be the case if the cable were not fitted with the fin devices and consequently allowed to adopt the approximately catenoidal configuration hereinbefore discussed. This smaller value of β is invariant with depth of burial of the cable and establishes a determinable reduction of the angle of attack of the terminal anchor such that it can continue to produce a useful burial force at the cable end. Thus, the burial force furnished by the anchor 21 remains large and, further, is not progressively opposed by increasing penetration resistance forces acting on the buried portion of the cable. The burial depth of the anchor 21 is no longer limited by the cable penetration resistance but by the length of the finned portion of cable fitted. Therefore, by suitably selecting the length of finned cable, the depth of burial of the anchor and, hence, the holding power of the anchor can be increased at will up to the final limit set by the strength of the materials used in the construction of the anchor-cable system.

To prevent clogging of the end clearances between the sleeve 20, 40 and the collars of fairings 24, 25 (or 41) by the material of the sea bed, for example sand, ample clearances are provided between the sleeve and the collars to permit the sand etc. to pass freely from the clearances. Modifications are, of course, possible in the fin devices, for example, the fins could be simply mounted on a pair of spaced collars on the wire cable with an interposed sleeve on the cable serving to locate the device. Again, a sufficient degree of freedom of movement (or play) would be arranged between the collars and the cable/sleeve to

prevent clogging by sand or the like. Also, it would, of course, be possible to dispense with the middle fin 31, 46.

It will be understood that, for permanent mooring applications where an anchor and cable is positioned underwater on the sea bed there will be no necessity for pivoting of the flukes of the anchor 1 nor of the burial fins 26, 44 in the devices 22. Thus a fixed fluke terminal anchor and device with non-pivoting fins may be used for permanent moorings provided the fin devices 22 are all identically orientated on the cable and the terminal anchor 21 is similarly orientated so that normal functioning of the anchor-cable system ensues after placement of the anchor and cable in engagement with the sea bed when a horizontal pull is applied to the cable. It will be appreciated therefore that any burying anchor may be used at the end of a cable mounted with one or more of the fin devices 22 to form an anchor-cable system within the scope of the present invention.

Whereas hereinbefore, the present invention has been described for mooring vessels at sea, it will be understood that the invention is equally applicable for mooring vessels in rivers, lakes or like waters.

WHAT I CLAIM IS:—

1. A cable for attachment to an anchor for mooring an object to a mooring bed including one or more spaced devices adjacent to the anchor end of the cable, at least one surface of each device being inclined relative to the cable axis and when said device is in a vertical burial attitude being inclined to the horizontal whereby, on penetration of the portion of the cable including the devices into the mooring bed when a substantially horizontal pull is applied to the anchor cable, the inclined surfaces of each device produce burial forces capable of burying the device and counteracting the vertical drag forces developed by the adjacent buried portion of the cable such that said portion is constrained to depart from an approximately catenoidal configuration and tend to adopt a substantially linear configuration or a curvature that is reverse to said catenoidal configuration.

2. A cable as claimed in claim 1, wherein the inclined surface of each cable-mounted device is a surface of an inclined fin forming part of the device.

3. A cable as claimed in claim 2, wherein the centre of area of the inclined fin of each device is offset from the axis of the cable.

4. A cable as claimed in claim 2 or 3, wherein at least three fifths of the total area of the inclined fin of each device lies at one side of the cable axis.

5. A cable as claimed in claim 3 or 4, wherein the fin-bearing portion of each finned device is pivotably mounted about the cable axis to permit the offset inclined fin to trail



to the movement of the ship 1, the anchor 21 and the portion of the cable 20A adjacent thereto penetrate into the sea bed 3. Penetration of the sea bed surface by the cable 20 under the action of the terminal anchor 21 causes the fin devices 22 to engage the sea bed with the result that burial forces are developed at the inclined fins 26, 44 of the fin devices 22. These burial forces bury each fin device 22 and counteract the soil penetration resistance forces acting vertically on the cable between each fin device 22 so that the buried portion of the cable tends eventually to adopt a substantially linear configuration with the inclined fins 26, 44 of the fin devices 22 in parallel alignment and trailing behind the cable due to the action of the central fin 31, 46 and the offset disposition of the fins 26, 44.

It will be understood that the fin devices 22 will automatically establish the correct trailing aspect, on engaging the sea bed 3, owing to the separation of the centre of area of the fins 26, 44 from the axis of the cable and the disposition of the fins as a group.

Thus, the angle of inclination β of the anchor end of the cable to the horizontal, is maintained smaller than would be the case if the cable were not fitted with the fin devices and consequently allowed to adopt the approximately catenoidal configuration hereinbefore discussed. This smaller value of β is invariant with depth of burial of the cable and establishes a determinable reduction of the angle of attack of the terminal anchor such that it can continue to produce a useful burial force at the cable end. Thus, the burial force furnished by the anchor 21 remains large and, further, is not progressively opposed by increasing penetration resistance forces acting on the buried portion of the cable. The burial depth of the anchor 21 is no longer limited by the cable penetration resistance but by the length of the finned portion of cable fitted. Therefore, by suitably selecting the length of finned cable, the depth of burial of the anchor and, hence, the holding power of the anchor can be increased at will up to the final limit set by the strength of the materials used in the construction of the anchor-cable system.

To prevent clogging of the end clearances between the sleeve 20, 40 and the collars of fairings 24, 25 (or 41) by the material of the sea bed, for example sand, ample clearances are provided between the sleeve and the collars to permit the sand etc. to pass freely from the clearances. Modifications are, of course, possible in the fin devices, for example, the fins could be simply mounted on a pair of spaced collars on the wire cable with an interposed sleeve on the cable serving to locate the device. Again, a sufficient degree of freedom of movement (or play) would be arranged between the collars and the cable/sleeve to

prevent clogging by sand or the like. Also, it would, of course, be possible to dispense with the middle fin 31, 46.

It will be understood that, for permanent mooring applications where an anchor and cable is positioned underwater on the sea bed there will be no necessity for pivoting of the flukes of the anchor 1 nor of the burial fins 26, 44 in the devices 22. Thus a fixed fluke terminal anchor and device with non-pivoting fins may be used for permanent moorings provided the fin devices 22 are all identically orientated on the cable and the terminal anchor 21 is similarly orientated so that normal functioning of the anchor-cable system ensues after placement of the anchor and cable in engagement with the sea bed when a horizontal pull is applied to the cable. It will be appreciated therefore that any burying anchor may be used at the end of a cable mounted with one or more of the fin devices 22 to form an anchor-cable system within the scope of the present invention.

Whereas hereinbefore, the present invention has been described for mooring vessels at sea, it will be understood that the invention is equally applicable for mooring vessels in rivers, lakes or like waters.

WHAT I CLAIM IS:—

1. A cable for attachment to an anchor for mooring an object to a mooring bed including one or more spaced devices adjacent to the anchor end of the cable, at least one surface of each device being inclined relative to the cable axis and when said device is in a vertical burial attitude being inclined to the horizontal whereby, on penetration of the portion of the cable including the devices into the mooring bed when a substantially horizontal pull is applied to the anchor cable, the inclined surfaces of each device produce burial forces capable of burying the device and counteracting the vertical drag forces developed by the adjacent buried portion of the cable such that said portion is constrained to depart from an approximately catenoidal configuration and tend to adopt a substantially linear configuration or a curvature that is reverse to said catenoidal configuration.

2. A cable as claimed in claim 1, wherein the inclined surface of each cable-mounted device is a surface of an inclined fin forming part of the device.

3. A cable as claimed in claim 2, wherein the centre of area of the inclined fin of each device is offset from the axis of the cable.

4. A cable as claimed in claim 2 or 3, wherein at least three fifths of the total area of the inclined fin of each device lies at one side of the cable axis.

5. A cable as claimed in claim 3 or 4, wherein the fin-bearing portion of each finned device is pivotably mounted about the cable axis to permit the offset inclined fin to trail



behind the cable and so adopt automatically an effective working orientation.

6. A cable as claimed in any one of claims 2 to 5, wherein each cable-mounting device has two or more burial fins inclined relative to each other as well as to the cable axis such that the device is symmetrical about a vertical plane bisecting the device when the device is in a vertical burial attitude, and such that the fins are in an anhedral configuration.

7. A cable as claimed in claim 6, wherein the disposition of the inclined burial fin surfaces of each device is such that, when said device is interacting with the mooring bed surface in a reverse attitude to the vertical burial attitude, the resultant force vector produced by the portions of burial fin lying at either side of the vertical plane of symmetry bisecting the device and making contact with the surface material of the mooring bed, lies on a straight line intersecting the vertical plane of symmetry at a point below the axis of the portion of the cable trailing immediately behind the device.

8. A cable as claimed in any preceding claim, wherein a plurality of devices are mounted on the cable, the angles of inclination relative to the cable axis of the inclined surfaces of all of the devices being equal in magnitude to each other.

9. A cable as claimed in any preceding claim, wherein the angle of inclination to the cable axis of the line of intersection of the inclined burial surfaces of each device with the plane of symmetry of each device is within the range 15° to 60° , and particularly 30° to 60° .

10. A device for use with an anchor cable for mooring an object to a mooring bed, including means for attachment of the device to the anchor cable such that at least one surface of the device is inclined relative to the cable axis and in a vertical burial attitude of the device is inclined relative to the horizontal whereby, on penetration of the portion of the cable carrying the device into the mooring bed when a substantially horizontal pull is applied to the anchor cable, the inclined surface of the device produces burial forces capable of burying the device and counteracting the vertical drag forces developed by the adjacent buried portion of the cable such that said portion is constrained to depart from an approximately catenoidal configuration and tend to adopt a substantially linear configuration or a curvature that is reverse to said catenoidal configuration.

11. A device as claimed in claim 10, wherein the inclined surface is a surface of an inclined fin forming part of the device.

12. A device as claimed in claim 11, wherein the centre of area of the inclined fin is offset from the axis of the cable.

13. A device as claimed in claim 11 or 12, wherein at least three fifths of the total

area of the inclined fin lies at one side of the cable axis.

14. A device as claimed in claim 12 or 13, wherein the fin-bearing portion of the device is pivotally mounted about the cable axis to permit the offset inclined fin to trail behind the cable and so adopt automatically an effective working orientation.

15. A device as claimed in any one of claims 11 to 14, wherein two or more burial fins are inclined relative to each other as well as to the cable axis such that the device is symmetrical about a vertical plane bisecting the device when the device is in a vertical burial attitude, and such that the fins are in an anhedral configuration.

16. A device as claimed in claim 15, wherein the disposition of the inclined burial fin surfaces is such that when said device is interacting with the mooring bed surface in a reverse attitude to a vertical burial attitude, the resultant force vector produced by the portions of burial fin lying at either side of the vertical plane of symmetry bisecting the device and making contact with the surface material of the mooring bed, lies in a straight line intersecting the vertical plane of symmetry at a point below the axis of the portion of the cable trailing immediately behind the device.

17. A device as claimed in any one of claims 10 to 16, wherein the angle of inclination to the device axis (which is co-linear with the cable axis when mounted on the cable) of the line of intersection of the inclined burial surfaces with the plane of symmetry of the device is within the range 15° to 60° , and particularly 30° to 60° .

18. A device as claimed in claim 17, wherein there are provided a forward clamping collar positionable on a wire hawser cable having an annular recess on an end wall thereof, a sleeve on which are mounted a pair of offset opposed fins inclined relative to the axis of the collar and to each other and a third fin between the opposed fins and upstanding from the sleeve, the leading end of the sleeve being insertable into the recess of the forward collar whilst the trailing end of the sleeve is provided with a recess, and a trailing clamping collar insertable into the recess of the sleeve to locate the sleeve rotatably in position on the wire hawser cable.

19. A device as claimed in claim 17, for location on a chain cable, wherein there are provided a forward fairing carrying a chain ring and having an annular recess on an end wall thereof, a sleeve on which are mounted a pair of offset opposed fins inclined relative to the axis of the fairing and to each other and a third fin between the opposed fins and upstanding from the sleeve, the leading end of the sleeve being locatable into the recess of the forward fairing and fitting pivotably about a rearwardly projecting cylindrical

projection of the fairing which serves as a bearing for the sleeve.

20. A device as claimed in claim 19, wherein the trailing end of the sleeve is provided also with an annular recess into which a retaining collar may be fitted while encircling the rear end of the cylindrical projection of the forward fairing.

21. A device as claimed in claim 19, wherein a chain ring is positioned at the rear of the projection and both retaining collar and chain ring are secured to the projection.

22. A cable for attachment to an anchor substantially as hereinbefore described with

reference to Figs. 1 to 6 of the accompanying drawings.

23. A finned device for use with an anchor cable substantially as hereinbefore described with reference to Figs. 1 to 5 of the accompanying drawings.

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