



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁵ : B63B 21/32	A1	(11) International Publication Number: WO 92/20569 (43) International Publication Date: 26 November 1992 (26.11.92)
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(21) International Application Number: PCT/GB92/00921

(22) International Filing Date: 21 May 1992 (21.05.92)

(30) Priority data:
9110950.4 21 May 1991 (21.05.91) GB

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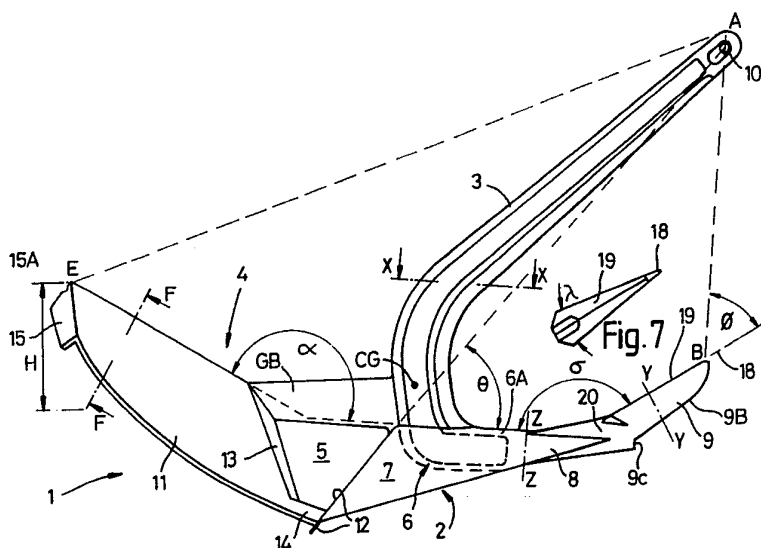
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(81) Designated States: AT (European patent), AU, BE (European patent), BR, CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FI, FR (European patent), GB, GB (European patent), GR (European patent), IT (European patent), JP, KR, LU (European patent), MC (European patent), NL (European patent), NO, PL, RU, SE (European patent), US.

Published

With international search report.

(54) Title: IMPROVED MARINE ANCHOR



(57) Abstract

A marine anchor (1) has an anhedral fluke (2) with a shank (3) attached thereto including an anchor line attachment point (10). A rear plate assembly (4) behind the fluke (2) is inclined at an obtuse angle (α) to the fluke (2) and serves to provide a turning moment about the attachment point (10) countering turning moments produced by friction effect on the fluke and the shank and by edge resistance during anchor burial to give improved anchor holding power while soil escapes passage (5) between the rear assembly (4) and the fluke (2) allows escape of sand and soft mud passing over the fluke. Peripheral edges (4A) of the rear assembly (4) are shaped to cause rolling of the anchor to a burial position. An upturned toe portion (9) at the front of the fluke encourages effective anchor operation in clay soils while also facilitating rock gripping by the anchor.

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IMPROVED MARINE ANCHOR.

The present invention relates to marine anchors.

The fundamental requirement of a marine anchor is an ability to dig into a mooring bed when pulled forwardly, and to remain stable in the dug-in attitude in the bed when pulled further. It is also well established that for high holding power the anchor should be relatively deeply buried during anchor setting. The nature of mooring beds varies enormously, for example, from hard soils of granular non-cohesive dense gravels and sands or cohesive stiff clays to soft soils of cohesive muds. The mooring bed may also be rocky whereupon the anchors must be able to hook satisfactorily onto a rock for mooring. Satisfactory operation of an anchor in a particular mooring bed has necessitated the anchor to have a particular geometry including a fluke angle compatible with the mooring bed soil. The fluke angle is the angle formed between the fluke and a line in a fore-and-aft plane of symmetry of the anchor extending between the rear of the fluke and an anchor line attachment point in the forward end of the shank. At present, it is known, (see, for example, The Quarterly Transactions of the Institute of Naval Architects, Vol. 92, No. 4, October 1950, pps. 341-343) that for operation in a sand bed a low fluke angle in the range 23° to 32° provides peak holding power in the deepest burying anchors. Fluke angles of 25° to 32° for medium dense to loose sands generally provide satisfactory performance. For a relatively soft mud bed, the fluke angle for peak performance is larger and is in the region of 50° to 55° . In sand, with fluke angles over 32° , the moment about the anchor line attachment point of the resultant of soil normal pressure and friction forces on an anchor fluke is insufficient to counterbalance the sum of the moments about the same point of soil edge resistance force on the fluke and soil resistance force on the shank during initial penetration. The anchor is, in consequence, longitudinally unstable during pulling, and rotates about the attachment point into a nose-down attitude wherein it fails to bury

below the surface of the mooring bed or even breaks out of the soil altogether. A fluke angle of 32° or less has thus generally been adopted for the deepest burying anchors to permit effective use in both hard and soft soils. The resulting disadvantage in soft soils is usually mitigated by maximally increasing fluke area at the cost of reduced structural strength for hooking on rocks. However, even with increased fluke area, such anchors typically provide a soft mud performance less than 15 per cent of their sand performance. This illustrates the problem involved in providing an anchor with a single compromise fluke angle capable of producing high holding capacity in both hard sand and soft mud.

The applicant's European Patent No. 0180609 describes a marine anchor which, by the provision of a barrier plate aligned with transverse non-cohesive soil flow at the rear of the fluke and with a restriction passage between the barrier plate and the fluke, causes a stalled wedge of mud to accumulate on the fluke during burial in a soft mud bed. This mud wedge shears between the leading edges of the fluke and the upper edges of the barrier at an angle of 20° to the fluke (which is set at a fluke angle of 30° for sand) so that an effective fluke angle of 50° is established at the incident-mud/stalled-mud-wedge interface. This large effective fluke angle at the surface of the stalled wedge enables the anchor to operate satisfactorily in soft mud. In a sand bed, the restriction passage, although too small to permit a significant through-flow of cohesive soil (mud), allows escape of non-cohesive soil (sand) aft from over the fluke whereby shearing occurs at the fluke surface so permitting effective operation of the anchor in sand at the actual fluke angle of 30° . However, although this arrangement does provide improved capacity in mud, burial does not occur as deep as in the case of an anchor having a large fluke angle. Consequently, the very high holding capacity in soft mud of the deep based large fluke angle anchor is not achieved although the holding capacity does appreciably exceed that of the anchor with a small (sand)

fluke angle when operating in mud. It is an object of the present invention to provide a marine anchor giving improved performance over the anchor of EP.0180609.

Another object of the present invention is to provide an improved marine anchor of the one-sided type (with the shank at one side only of the fluke) which self-orientates to a ground-engaging attitude when cast in an inverted position on and pulled horizontally over a mooring bed surface.

There can be problems in obtaining initial digging of an anchor in a hard clay bed, especially in the case of an anchor provided with means for self-orientating the anchor from an inverted position to a digging-in position, and it is a particular objective of the present invention to provide a marine anchor which obviates or mitigates this problem.

According to a first aspect of the present invention there is provided a marine anchor as set out in appended claim 1.

According to a second aspect of the present invention there is provided a marine anchor as set out in appended claim 8.

According to a further aspect of the present invention there is provided an anchor in accordance with appended claim 35.

An embodiment of the present invention will now be described by way of example with reference to the accompanying drawings wherein:-

Fig. 1 is a side view of a marine anchor in accordance with a first embodiment of the present invention;

Fig. 2 is a plan view through section X - X in Fig. 1;

Fig. 3 is a front view of the anchor;

Figs. 4, 5 and 6 show sections Y - Y, Z - Z and F - F respectively in Fig. 1;

Fig. 7 shows a toe portion of the fluke in Fig. 1 viewed normally to its upper surface;

Fig. 8 shows the sand flow paths over the anchor while burying deeply in sand due to a forward pull P applied to the anchor;

Fig. 9 shows the various forces and turning moments on the anchor when it is burying in a sand mooring bed as shown in Fig. 8; and

Fig. 10 shows a pictorial view of the anchor of Figs. 1 to 7 in a mooring bed engaging position with the fluke point ready to engage the soil.

Referring to Figs. 1 to 7, a marine anchor 1 is symmetrical about a fore-and-aft plane $M - M$ and comprises a fluke 2, a shank 3 attached at one end to the fluke 2, and including an anchor line attachment point 10 comprising a slotted hole at the shank end A remote from the fluke 2, and a rear assembly 4 serving to counter moments of frictional forces and edge resistance on the fluke 2 and on the shank 3 about point 10, soil escape apertures 5 being located between fluke 2 and the rear assembly 4. More specifically, a base member 6 provides the shank 3 and includes arms 6A and 6B carrying tapered fluke plates 7 and the rear assembly 4 respectively, the arm 6A additionally providing a fluke forward portion 8 which forms a triangular fluke in conjunction with tapered fluke plates 7, and a toe portion 9 culminating in a point (B in Figs. 1 and 10). The slotted hole at point 10 serves to receive a shackle for attachment of an anchor line.

The fluke angle θ is the angle between fluke 2 and a line in the plane of symmetry joining point 10 to the rear of fluke 2. Angle θ is shown as about 50° being in the preferred range of 32° to 58° .

The fluke 2 is of anhedral form with each fluke plate 7 having an anhedral angle β relative to a plane at right angles to the plane of symmetry and containing the intersection of plates 7. In this example, β is 29° but may be in the range 10° to 40° .

The rear assembly 4 is of plate form comprising a pair of plates 11 joined in the plane of symmetry so as to provide a backwardly directed shallow V in section and

presenting two forwardly facing plate surfaces 11A, 11B constituting soil pressure reaction surfaces located aft of and extending over the full transverse span of aperture 5. As shown in Fig. 6, the V arranged plates are each inclined at an anedral angle δ relative to a plane at right angles to the plane of symmetry and containing the intersection of surfaces 11A and 11B. Angle δ is shown as 22.5° being in a preferred range of 10° to 35° . The plate surfaces 11A, 11B intersect in a line forming a forwardly-directed obtuse angle α with the intersection line of plates 7 of fluke 2. Angle α is shown as 155° being in the preferred range of 120° to 170° .

The rear of fluke 2 is strengthened by an inclined lower transverse rib plate 12 which lies in a plane which has minimum separation from point 10 aft and above point 10. When projected in the direction of the intersection of plates 7 with the plane of symmetry, the area of rib plate 12 is approximately half of the area of assembly 4 (Fig. 3) and so contributes approximately one third of the total resistance area of the anchor when fully buried in mud.

The rear assembly also includes forward transverse strengthening rib plate 13 formed at the forward edges of plates 11, and aft transverse stiffening rib plates 15 formed with anhedral between them at the rear edges of plates 11. Fluke extension plates 14 between the assembly 4 and the fluke 2 flank the apertures 5 and serve to extend the peripheral edges of plates 11 to the transverse extremities of fluke 2 to prevent chains, ropes and the like from entering and jamming in the apertures 5. The rib plates 15 carry between them an eye 15A to which a pendant line may be secured for retrieval of the anchor.

The anchor 1 is self-orientating and to this end the peripheral edge 4A of the assembly 4 is of cardioidal shape to cause rolling of the anchor 1 from an inverted position to a mooring bed engaging position as shown in Fig. 10. When the anchor 1 is placed inverted on a horizontal plane surface of a firm mooring bed contact will be made substantially only at the top E of the assembly 4 and at

forward point A on the shank. Only points X on the curves EC or ED and points at A and B make contact with the horizontal surface of the mooring bed when the anchor 1 is pulled thereover by pulling at the shackle point 10 at the end A of the shank 3.

Curves EC and ED in periphery 4A each lies substantially in a skewed axis elliptical conical surface with the apex of the cone adjacent the shackle end (A) of the shank 3, the skewed axis of the cone intersecting the plane of symmetry at a point, with the minor axis of the elliptical cross-section of the cone lying athwart the plane of symmetry of the anchor. Thus, each of curves EC and ED constitutes a spiral curve relative to the centre of gravity CG (Fig. 1) of anchor 1.

In the inverted position, the centre of gravity CG (Fig. 1) of the anchor is high above the line containing the support points at A and E. The anchor is thus unstable in the inverted position and so quickly topples to one side of a vertical plane through A and E. The contact point at E migrates along EC or ED as a moving contact point X. The skewed-axis nature of the conical surface, in which each spiral curve EC or ED lies, maintains a horizontal displacement of the centre of gravity CG from one side of a vertical plane through A and X and so maintains a gravitational transverse turning moment which rolls the anchor along periphery 4A until the point of the toe portion 9 of the fluke 2 is brought into penetrative contact with the mooring bed surface (Point B in Fig. 10). The anchor is now in one of two possible stable positions one of which is shown in Fig. 10. In this stable position, three-point contact is present with either left-hand fluke extension 14 or right-hand fluke extension 14 in contact with the mooring bed surface.

The shank 3 is of a partially straight form with its centre-line substantially separated from line AE so that the mass of the shank contributes considerably to the gravitational rolling moment which turns the anchor into penetrative engagement with the mooring bed. Also, the

substantial concavity between line AE and the anchor, achieved by this location of the shank, precludes serious obstruction to the rolling action.

The toe portion 9 which is of robust solid form upwardly inclined to form a rearwardly-directed obtuse angle δ between its upper surface and the intersection line between plates 7 of fluke 2. Angle δ is shown as 146° being in a preferred range of 130° to 170° . The adjacent fluke portion 8 is also of robust solid form with a generally triangular cross-section as shown in Fig. 5. Portion 8 serves as a ballast weight and as a strong support for the forward edges of plates 7 capable of sustaining the high pressure loading occurring on the fluke of the anchor 1 when burying in firm to hard mooring beds. The toe portion 9 is a forward portion of arm 6A formed to constitute a small auxiliary triangular fluke of generally arrow or spear head form which precedes the main fluke comprising plates 7 and portion 8. This auxiliary fluke has a rearward major upper surface 19 and a forward minor upper surface 18 inclined relative to each other. The rearward major upper surface 19 forms an external angle ϕ with a line joining point 10 in the shank 3 to a foremost point of surface 19 in the plane of symmetry. Angle ϕ is shown as 56° being in the preferred range of 50° to 65° and less than 70° .

The upper major surface 19 in the view normal to the surface shown in Fig. 7 is generally of elongate triangular shape with the sharp apex forward and the side edges including an angle λ . Angle λ is shown as 18° , being in a preferred range of 10° to 30° . The minor upper surface 18 is less than 5 per cent of the area of surface 19 and is located in a plane at right angles to the line joining point 10 in the shank to a foremost point of surface 19 in the plane of symmetry. This surface 18 serves to provide sufficient bearing area at the point of toe 9 to sustain a point load of 71 times anchor weight without bearing failure occurring whilst remaining sufficiently small to avoid preventing penetration of the point of toe 9 into very hard mooring bed surfaces such as firm clay.

A typical substantially triangular section through the toe portion 9 is shown in Fig. 4. The lower apex of the section corresponds with a sabre-like lower edge 9B of toe portion 9. A step 9C is present in edge 9B. This acts as a tripping fulcrum which prevents skidding of edge 9B on stiff clay and trips anchor 1 to topple sideways to bring the point of toe 9 into engagement with the stiff clay. The upper major surface 19 may be planar or of anhedral form like fluke 2. Each section of toe 9 has sufficient depth and area to sustain the bending moment and shear force due to a substantial point load, and in particular a point load 71 times anchor weight applied at the junction between major upper surface 19 and minor upper surface 18. The sabre-like lower edge of toe portion 9 is provided to cleave the mooring bed soil with minimum resistance when the anchor is deeply buried with the incident relative soil flow occurring in the direction of arrow EF in Fig. 9.

Passages 20 are present between the solid auxiliary fluke of toe portion 9 and fluke forward portion 8. These passages 20 increase in transverse cross-sectional area in an afterwards direction to promote free transit of mooring bed soil there-through without jamming. The inclined length of toe portion 9 co-operates with the fluke extensions 14 to keep the edge of fluke plate 7 raised clear of the mooring bed surface when the anchor is in three point contact with the mooring bed surface as shown in Fig. 10. This permits the auxiliary fluke of toe portion 9 to penetrate fully into a firm or hard mooring bed surface before edge resistance from fluke portion 8 and plate 7 arises on contacting the surface.

The rear assembly 4 enables the anchor 1 to bury deeply in sand even when the fluke angle θ has a relatively high value exceeding 32° , and in this connection the plates 11A, 11B aft of aperture 5 define a barrier to sand flow.

Fig. 8 shows (arrowed) relative movement flow lines of sand over and about a moving buried anchor 1 adjacent its plane of symmetry. The flowing sand changes direction due to interaction with fluke 2 and shears along planes 21

emanating from the edges of fluke 2. Following shearing, the flow is generally parallel to plates 7 of fluke 2 with parting of the flow occurring about stalled sand wedge W which forms on the faces 11A, 11B of the barrier assembly 4. One part of the sand flow slides over an upper surface of wedge W which is substantially aligned with the sand flow and another part flows over rib plate 12 and under a lower surface of wedge W before exiting aft through soil escape apertures 5 to fill a void tending to form continuously behind the fluke. Sand flow overtopping barrier 4 cascades downwards to fill a void tending to form continuously behind the barrier.

The stalled wedge W moves with the anchor and effectively forms part of the anchor when operating in sand. Sand pressure and movement at the surface of wedge W produces normal tangential forces which are transmitted through the body of the wedge onto the forward facing surface 11A, 11B of the barrier. The surface area and shape of the wedge W and, hence, the size and direction of the resultant force applied to the barrier depends on the inclination angle α and the area of the barrier. For a given area of barrier, the angle α determines the position and direction of the resultant force RW on the upper surface of wedge W riding on faces 11A, 11B of the barrier and, hence the magnitude of the turning moment produced by RW about shackle point 10. This desirable turning moment is appreciable when α is in the range 130° to 165° and reaches a peak when α is between 145° and 155° . The area of barrier 4, when viewed in the plane of symmetry at right angles to the intersection line of surfaces 11A and 11B, lies in the range 1 to 22 times the area of fluke 2 viewed in the plane of symmetry at right angles to the intersection of plates 7, with the optimum area being between 1.5 and 1.9 times the area of fluke 2 when α is between 140° and 160° . Since there is no need to minimise the size of apertures 5 to constitute a choke gap for restricting through flow of mud to produce a stalled mud wedge on the fluke when the anchor is operating in a mud mooring bed, the width of

apertures 5 measured in a plane parallel to the plane of symmetry can be in the range 20 to 70 per cent of the length of the intercept between plates 7 of fluke 2. Figs. 1 - 3 show a width of 43 per cent which corresponds to a sand flow cross section area in each aperture 5 equal to the area of a triangle at either side of the plane of symmetry of anchor 1, seen in front elevation (Fig. 3), bounded by plate 7 and a line 22 joining the outer extremity of plate 7 to the uppermost point in barrier 4. This ensures that sufficient sand discharges through apertures 5 to maintain the flow regime shown in Fig. 8 and prevent sand wedge W from bridging between the outer edges of barrier 4 and fluke 2 thus increasing the effective fluke angle high enough to prevent deep burial of anchor 1 in sand.

Fig. 9 shows the force vectors and moments developed on the buried anchor due to the sand flow pattern shown in Fig. 8. Friction forces tangential to surfaces are labelled F and normal pressure forces at right angles to these surfaces are labelled N. Resultant force vectors due to F and N are labelled R with subscripts F, 5, W, and 15, denoting forces associated with the fluke, shank, wedge W upper surface, and ribs 15. For clarity, resultant forces on rib plate 12 and the under surface of wedge W have not been shown since the opposed normal forces on these surfaces largely cancel out leaving the sum of the tangential friction forces as the combined resultant force. EF is shown as a vector representing the edge resistance force on the fluke structure.

With assembly 4 removed from anchor 1, the clockwise turning moments due to tangential and normal forces on plate 12, in the presence of zero turning movement from RF, are too small to balance the anti-clockwise turning moments produced by RS and EF. Additionally, EF is particularly large in dense sand since it is produced at the edges of fluke 2 and toe portion 9 before the sand is loosened by passage through shear planes 21 (Fig. 8). A net anti-clockwise turning moment would thus be present which would tip up the rear of fluke 2 and decrease the vertical

components to forces on plates 7 and 12 so preventing the anchor from burying deeply. As in prior art anchors, this can be avoided by arranging the direction of RF to pass with sufficient clearance above shackle point 10 to produce a balancing clockwise turning moment. In dense sand, reduction of fluke angle θ from the 52° shown in Fig. 1 to 30° or less would thus be necessary.

With the barrier assembly 4 now installed on anchor 1 at an angle α of 155° , forces due to pressure and movement of said on ribs 15 and on the stalled sand wedge W at the face of barrier 4 are developed. The resultant force R15 on rib plates 15 is small but produces an appreciable clockwise turning moment due to the large separation of its line of action from shackle point 10. The normal force on the lower surface of wdg W cancels with the normal force on plate 12 leaving the corresponding friction forces acting together to produce a clockwise turning moment about shackle point 10. The large resultant force RW at the upper surface of wedge W lies in a direction having a large separation from shackle point 10 and so produces a major clockwise turning moment. The sum of these clockwise turning moments is sufficient to balance the combined anti-clockwise turning moments produced by RS and EF without help from a clockwise moment from RF which would require a reduction in fluke angle θ from values considered by convectional wisdom as too large for effective burying in dense sand. This arrangement of barrier 4 and apertures 5 can thus be utilized to provide an anchor capable of burying deeply in dense sand while using a fluke angle much larger than hitherto possible. This large fluke angle is then well suited for efficient operation of the anchor in soft mud. This arrangement of barrier 4 and apertures 5 permits an anchor with a fixed fluke angle as high as 52° to equal its mud performance when operating in dense sand without the traditional necessity of reducing the fluke angle to 30° or less.

In use, an anchor 1, with a fluke angle θ of 52° as shown in Figs. 1 to 10, may be cast inverted on a mooring

bed surface and dragged by a horizontal pull applied to the shackle point 10 of the shank 3.

On a firm mooring bed surface, the anchor will topple about line AE (Fig. 1) to one side and will then rapidly roll on periphery 4A until it is in three-point contact with the mooring bed as shown in Fig. 10.

On a soft mud mooring bed, the inverted anchor will sink into the soft surface under its own weight. Penetration will occur mainly at the rear barrier assembly 4 in the region of point E (Fig. 1) but is kept small due to the support provided by the area of ribs 15 bearing on the mud. Forward motion causes the barrier plates to plane and rise towards the surface of the mud. Instability in this inverted position due to the anhedron between ribs 15 and between plates 11 at the inverted pack of the barrier 4, the curved periphery 4A, and the elevated position of the centre of gravity CG initiates rolling which continues until three-point contact of the soft mud surface is achieved (in effect) as in the case of the firm mooring bed.

Further dragging causes toe 9 to penetrate into the mooring bed where soil pressure on the obliquely presented uppermost side face of toe 9 causes it to dig in sideways under the anchor. Simultaneously, soil pressure on the major upper surface 19 of toe 9 causes it to bury completely into the mooring bed and start portion 8 of fluke 2 digging also. The sideways force on toe 9 acts to initiate rolling of the anchor a burial of fluke 2 proceeds. The extension plate 14, in contact with the soil at one side of anchor 1, develops sufficient resistance force to act as a fulcrum about which the burial force on fluke 2 now acts to roll the anchor to the final upright digging attitude with the plane of symmetry M - M (Figs. 2 and 3) vertical.

In sand, the relative soil flow pattern shown in Fig. 8 develops during burying and longitudinally stabilises the anchor as shown in Fig. 9 and described previously. In mud, the soil flows up and over the fluke and up and over the barrier without forming a stalled wedge of mud on the fluke in advance of the barrier. Sliding of the soil

occurs at the fluke surface both in sand and in mud but since the fluke angle is large, deep penetration and consequent high performance is achieved in mud as well as in sand.

When burying deeply in mud the intersection in the plane of symmetry of fluke plates 7 of anchor 1 ultimately becomes approximately horizontal with the mud flowing edge-on to plates 7 as viewed in Fig. 3. In this attitude, the barrier 4 and rib plate 12 provide a major part of the horizontally-projected area of the anchor and, hence, the major part of its holding capacity. The combination of large fluke angle and large barrier counter moment in anchor 1 causes it to bury deeply in sand despite the presence of the larger fluke angle necessary for optimum performance in mud. In sand, the fluke 2 produces the major portion of the ultimate holding capacity although a substantial contribution does come from sand pressure on the barrier. Thus, the turning moment from the barrier allows fluke 2, inclined at a very large fluke angle in anchor 1 to provide high capacity in sand.

If the anchor 1 is cast on a hard rocky bottom, gravitational rolling to the three-point contact attitude of Fig. 10 occurs as before. Horizontal dragging causes toe 9 to track along the rocky surface and hook into any crevice or onto any projection in its path. The only possible location on anchor 1 at which rock hooking engagement can occur is at the point of toe 9 on minor upper surface 18 which, as mentioned before, can be designed to sustain a load of 71 times the weight of the anchor. Since the rock hooking load line between shackle point 10 and the upper minor surface 18 lies in the plane of symmetry M - M of anchor 1, no out-of-plane bending moments are impressed on shank 3. Consequently, the shank 3 may advantageously be of simple design and of relatively thin sections so minimising the resistance force RS and minimising the weight of the shank.

The present invention discloses an anchor which is self-righting and which can provide high holding capacity

exceeding 71 times its own weight in both firm sand and soft mud without need of fluke angle adjustment and which can sustain a load exceeding 71 times its own weight applied at the extreme forward point of its fluke due to hooking on rocks. This combination of features has not hitherto been available in marine anchors.

Modifications, of course, are possible. In particular it would be possible to have the anchor dismantlable to facilitate stowage, shipping etc. For example the rear assembly 4 could be removably fastened to the remainder of the anchor, and if desired this removable portion could include the arm 6B. Fastening could be achieved by the use of bolts suitably positioned to accommodate the load stressing on the in-use anchor. It would be possible to stow the removed portion in the space between the shank 3 and the fluke 2.

Also, in some inventive aspects the soil passage may be dispensed with.

CLAIMS.

1. A marine anchor, symmetrical about a fore-and-aft plane, comprising a shank (3) attached at a fluke angle θ to a fluke (2) at one end and including an anchor line attachment point (10) at or towards the other end, a rear assembly (4) located substantially aft of said fluke (2) and including a plate-like surface (11A, 11B) for reaction with incident mooring-bed soil, the intercept of said surface (11A, 11B) with said plane of symmetry forming a forwardly-opening obtuse angle α with the intercept of the fluke with said plane of symmetry, and soil escape passage means (5) located between said fluke and said rear assembly (4) characterised in that said rear assembly (4) is arranged and positioned to provide in the plane of symmetry (M-M) a counter turning moment on the anchor about said anchor line attachment point (10) which substantially counters opposing turning moments exerted on said anchor about said point (10) due to pressure and friction of incident non-cohesive mooring bed soil on said shank (3) and fluke (2) during anchor burial in such soil, and in that said soil escape passage means (15) are dimensioned to permit free escape of both granular non-cohesive soils and softmud cohesive soils passing over the fluke (2) without causing said soft like cohesive soils to be so retarded as to tend to accumulate over said fluke (2) in advance of said rear assembly (4).
2. An anchor according to claim 1, characterised in that said rear assembly (4) is located aft of the shank (3).
3. An anchor according to claim 1 or 2, characterised in that the fluke angle θ exceeds 32° .
4. An anchor according to claim 3, characterised in that the fluke angle θ is in the range 35° to 58° .
5. An anchor according to any one of the preceding claims, characterised in that the periphery (4A) of the rear assembly (4) is shaped to assist rolling of the anchor to an upright working position.

6. An anchor according to any one of the preceding claims, characterised in that an upturned toe member (9) is provided at the toe of the fluke (2).

7. An anchor according to claim 6, characterised in that said toe member (9) has a general triangular cross-section.

8. A marine anchor, symmetrical about a fore-and-aft plane, comprising a shank (3) attached to a fluke (2) at one end and including an anchor-line attachment point (10) at or towards the other end, and a rear assembly (4) located substantially aft of said fluke (2) and including a plate-like surface (11A, 11B) for reaction with mooring bed soil, intercepts of said plane of symmetry (M-M) with said fluke (2) and said plate-like surface (11A, 11B) forming a forwardly-opening obtuse angle $\sphericalangle$ characterised in that when the anchor is upside-down in contact with a horizontal mooring bed surface with said plane of symmetry (M-M) vertical and said shank (3) supported only just clear of the mooring bed by an anchor line attached at said attachment point (10), a point in the rear assembly (4) makes contact with said mooring bed surface to support the anchor in an unstable position thereon, and in that the rear assembly (4) includes peripheral edges (4A) which are curved to cause rolling of the anchor on said edges (4A) under gravity on toppling from said unstable position to bring the fluke (2) into contact with the mooring bed surface.

9. An anchor according to claim 8, characterised in that when rolling from an inverted position while supported by a hard horizontal mooring bed surface, the anchor can make contact with the mooring bed at only two points, being a point on said peripheral edge (4A) and a point on the shank (3) adjacent said anchor line attachment point (10), until the fluke point (8) makes penetrative contact with the mooring bed whereupon three contact points are established.

10. An anchor according to claims 8 or 9, characterised in that said curved peripheral edges (4A) are of cardioid form with the apex of the cardioid uppermost.

11. An anchor according to claims 8, 9 or 10, characterised in that said peripheral edges (4A) at one side of said plane

of symmetry (M-M) lie in an elliptical conical surface with the apex of the cone adjacent the anchor line attachment point (10) of the shank (3) and with the major axis of a cross-section of the cone lying in said plane of symmetry (M-M).

12. An anchor according to claims 8,9, or 10, characterised in that the peripheral curved edges (4A) of the rear assembly (4) is arranged such that the centre of gravity of the anchor is kept spaced from the side facing the fluke point of a vertical plane through the two contact points between the anchor and a horizontal mooring bed surface supporting it as it topples from an inverted position whereby a transverse turning movement due to gravity is maintained which progressively rolls the anchor round the peripheral curved edge (4A) until the fluke point is brought into penetrative engagement with the mooring bed surface.

13. An anchor according to claim 8, characterised in that said peripheral edges (4A) at either side of said plane of symmetry (M-M) form a substantially spiral curve relative to the centre of gravity of the anchor wherein points on said edges (4A) distal to the fluke (2) are further from said centre of gravity than points on said edges proximal to the fluke (2).

14. An anchor according to any one of the preceding claims, characterised in that the fluke (2) is of anhedral form with an anhedral angle β .

15. An anchor according to claim 14, characterised in that the anhedral angle β is in the range 10° to 40° .

16. An anchor according to any of the preceding claims, characterised in that the obtuse angle $\angle$ is in the range 120° to 170° .

17. An anchor according to claims 1 or 8, characterised in that the intercept of the plate-like surfaces (11A, 11B) of the rear assembly (4) with the plane of symmetry (M-M) forms an upwardly-opening obtuse angle with a line in the plane of

symmetry joining the anchor line attachment point to the rear of the fluke.

18. An anchor according to claim 17, characterised in that said upwardly-opening obtuse angle is in the range 90° to 145° .

19. An anchor according to any of the preceding claims, characterised in that the shank (3) is attached to the fluke (2) at one side only of the fluke (2).

20. An anchor according to any one of the preceding claims, characterised in that the rear assembly (4) comprises a transverse plate structure which extends through the plane of symmetry (M-M).

21. An anchor according to any of the preceding claims, characterised in that the rear assembly (4) includes a pair of forwardly-facing plate-like surfaces (11A, 11B) intersecting in the plane of symmetry (M-M) and each backwardly inclined at an angle of anhedral ϕ relative to a plane at right angles to the plane of symmetry (M-M) containing the intersection of the surfaces.

22. An anchor according to claim 21, characterised in that anhedral angle ϕ is in the range 10° to 30° .

23. An anchor according to any of claims 1 to 7, characterised in that the soil escape passage means (5) comprises an aperture between the rear assembly (4) and the fluke (2) extending over at least a quarter of the transverse width of the anchor fluke (2) astride the plane of symmetry.

24. An anchor according to any one of claims 1 to 7, characterised in that the separation between the rear assembly (4) and the fluke (2) in the plane of symmetry (M-

M) exceeds 10 per cent and mor especially 20 per cent of the length of the intercept of the fluke (2) with the plane of symmetry (M-M).

25. An anchor according to any of the preceding claims, characterised in that the projected area of the plate-like surfaces (11a, 11b) of the rear assembly (4) in a plane at right angles to the plane of symmetry (M-M) containing the intercept of the plate-like surfaces with the plane of symmetry in the range of 0.8 to 2.2 times the projected area of the fluke (2) projected onto a plane at right angles to the plane of symmetry (M-M) containing the intercept of the fluke (2) with the plane of symmetry.

26. An anchor according to any of claims 1 to 7, characterised in that side plate members (14) extend between the fluke (2) and the rear assembly (4) and flank the soil escape means (5).

27. An anchor according to any of the preceding claims, characterised in that the anchor includes a base member (6) comprising the shank (3) and a pair of support arms (6A, 6B) to respective ones of which arms the fluke (2) and the rear assembly (4) are attached.

28. An anchor according to any one of claims 1 to 7, characterised in that the total soil passage area of said soil passage means (5) exceeds one quarter of the calculated area obtained by multiplying the span (S) of fluke (2) by the distance (H) separating an uppermost point in the rear assembly (4) from a straight line containing the intersection of the upper surface of the fluke (2) with the plane of symmetry.

29. An anchor according to claim 28, characterised in that said soil passage area is less than said calculated area.

30. An anchor according to any one of the preceding claims, characterised in that a transverse stiffening rib (15) is located adjacent the upper edge of the rear assembly (4) serving as a support footing when the anchor is inverted on a soft mud mooring bed.

31. An anchor according to any one of the preceding claims characterised in that a transverse stiffening rib (13) is located adjacent the lowermost forward edges of said forwardly facing plate like surfaces (11A, 11B) of the rear assembly (4).

32. An anchor according to any one of the preceding claims, characterised in that a transverse stiffening rib (12) is located under the rear of upwardly-facing plate like surfaces (7) of the fluke (2) serving also as a barrier to movement of soft cohesive soil passing closely under the fluke (2).

33. An anchor according to claim 32, characterised in that said fluke transverse rib (12) is located in a plane which contains the rear edges of said upwardly-facing plate-like surfaces (7) and extends substantially in the direction of the anchor line attachment point (10).

34. An anchor according to claim 33, characterised in that the area of said fluke transverse rib (12) is in the range 0.2 to 0.7 times the area of said upwardly-facing plate-like surfaces (7) of said fluke (2).

35. A marine anchor of the one sided type, symmetrical about a fore-and-aft plane, comprising a shank (3) attached

to one side of a fluke (2) at one end and including an anchor-line attachment point (10) at or towards the other end, characterised in that said fluke includes a forward upstanding toe portion (9) which is upwardly inclined to an adjacent more rearward portion of the fluke (2) at an obtuse angle ϕ less than 175° measured in planes parallel to the plane of symmetry.

36. An anchor according to claim 35, characterised in that said obtuse angle ϕ is in the range of 130° to 170° .

37. An anchor according to claims 35 or 36 characterised in that intersection lines between planes parallel to the plane of symmetry (M-M) and a major upper surface (19) of said toe portion (9) of the fluke each form an acute angle θ with a plane at right angles to the plane of symmetry (M-M) which contains the anchor line attachment point (10) in the shank (3) and a foremost point (B) in said major upper surface (19).

38. An anchor according to claim 37, characterised in that said angle θ is less than 70° .

39. An anchor according to claims 37 or 38, characterised in that said acute angle θ lies in the size 50° to 65° .

40. An anchor according to any of claims 37 to 39, characterised in that said toe portion (9) has a minor upper surface (18) forward of and inclined to said major upper surface (19) and facing said anchor line attachment point (10).

41. An anchor according to claim 40, characterised in that said minor upper surface (18) is substantially at right angles to said line containing said anchor line attachment

point (10) and the foremost point (B) in the major upper surface (19) of said toe portion.

42. An anchor according to any of claims 35 to 41, characterised in that the lower periphery (9B) of said toe portion (9) comprises a sabre-like edge to cleave mooring bed material.

43. An anchor according to claim 42, characterised in that said lower periphery (9B) of said toe portion includes a tripping barb (9C) about which said anchor can topple to bring a foremost point in said toe portion (9) into penetrative contact with the mooring bed surface following penetration of said surface by said barb (9C).

44. An anchor according to any of claims 35 to 43, characterised in that said toe portion (9) is of substantially solid form with substantially triangular cross-section each having a lowermost apex located in the plane of symmetry (M-M).

45. An anchor according to any of claims 35 to 44, characterised in that said toe portion (9) is of pointed form when viewed in plan as in arrow and spear points to promote penetration of firm mooring beds.

46. An anchor according to any one of claims 35 to 45, characterised in that said toe portion (9) constitutes a forward auxiliary fluke preceding the anchor fluke proper.

47. An anchor according to claim 46, characterised in that said forward auxiliary fluke (9) is carried on an arm member (20) upstanding from said fluke proper.

48. An anchor according to claim 47, characterised in that passages are located at each side of said arm member (20)

between said forward auxiliary fluke (9) and said anchor fluke (2).

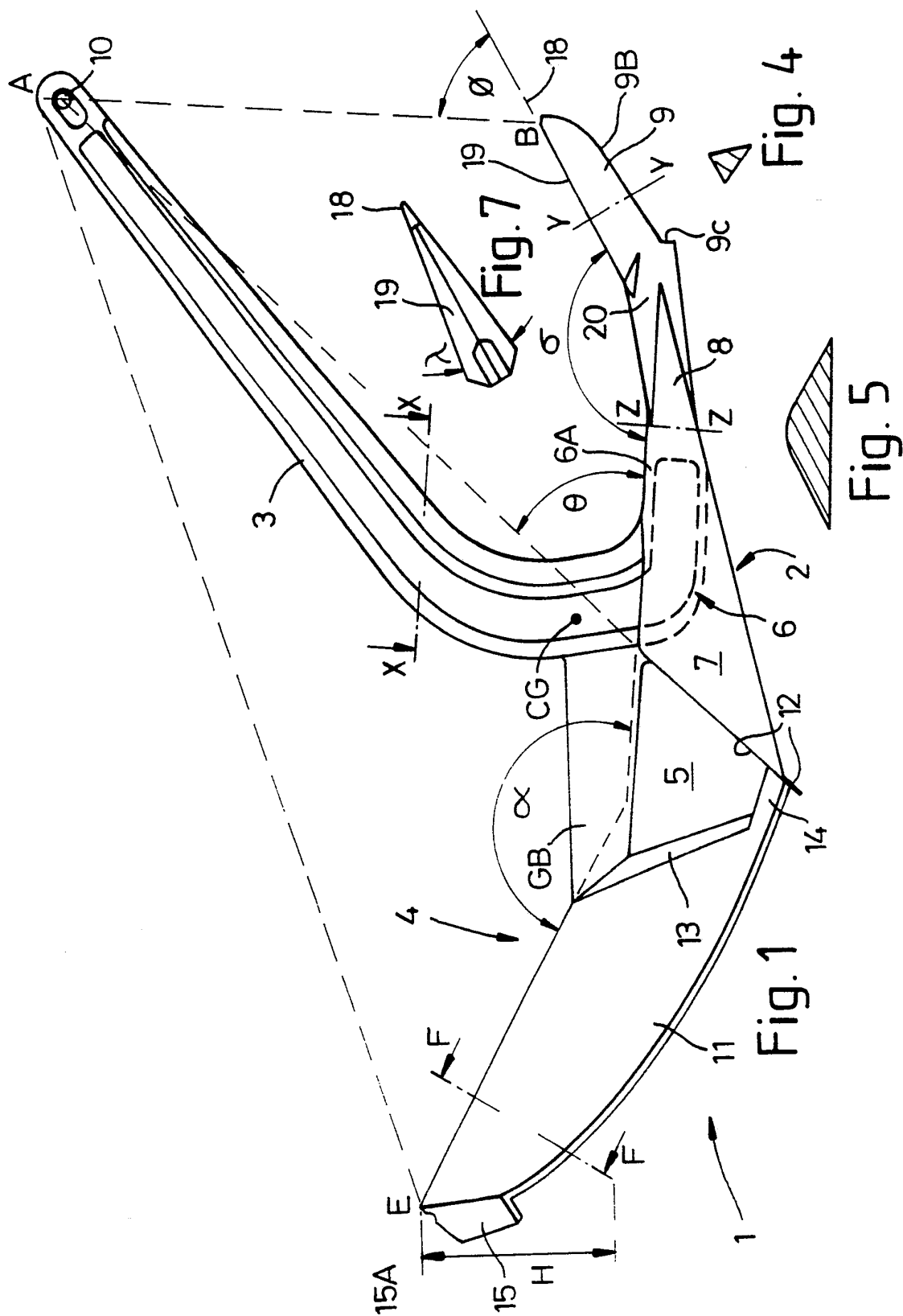
49. An anchor according to claim 48, characterised in that said passages are rearwardly divergent to promote soil flow therethrough.

50. An anchor according to any one of claims 35 to 49, characterised in that said toe portion (9) is part of an anchor base member (6) including the shank (3) with said base member (6) carrying fluke plate portions (7) arranged in anhedral form.

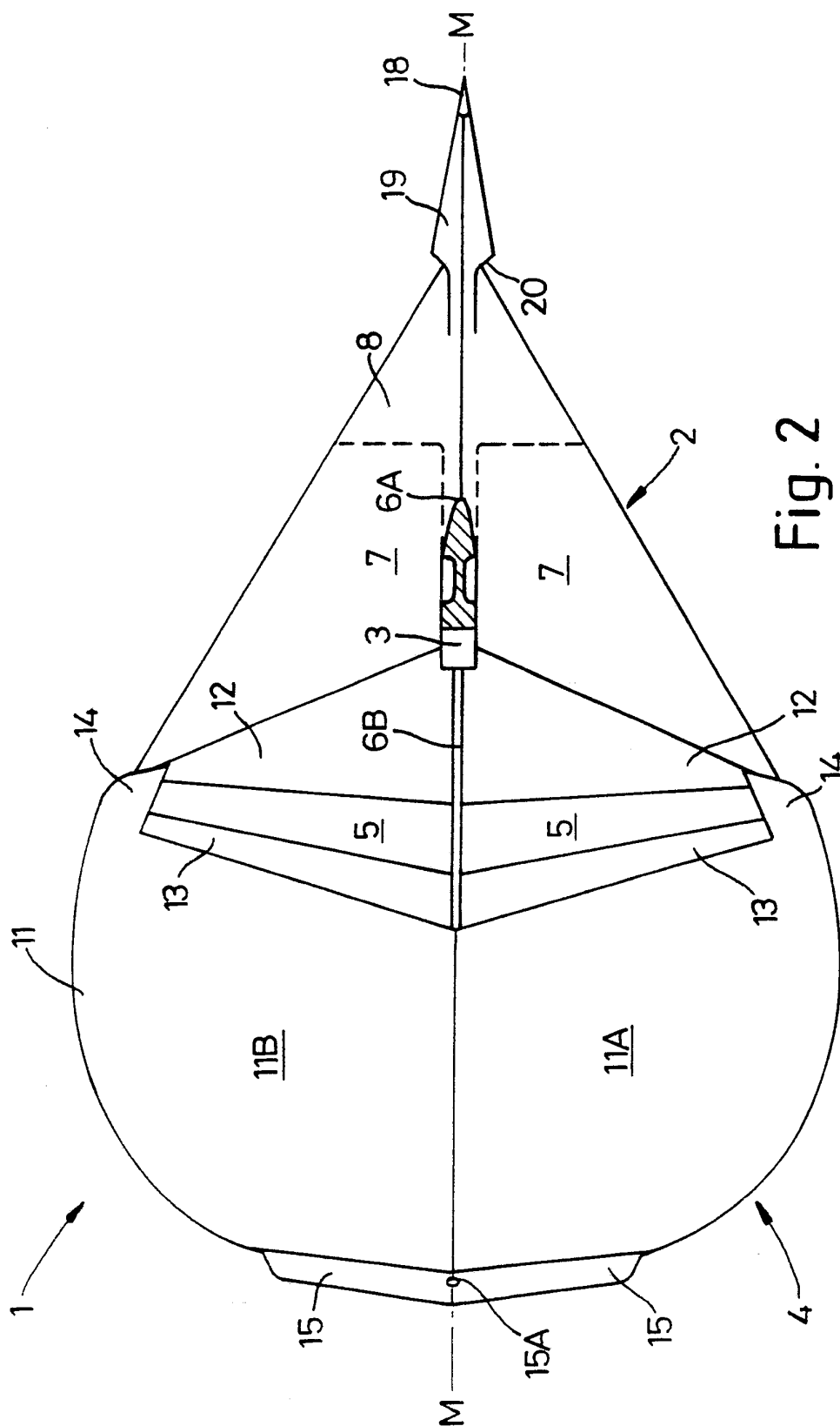
51. An anchor according to any of claims 35 to 50, characterised in that self-orientating means are provided to roll the anchor from an inverted position on a mooring bed to a position with the toe portion in penetrative engagement with the mooring bed surface.

52. An anchor according to any one of the preceding claims, characterised in that at least two of the characteristics of each of said claims is present in any mutually non-exclusive combination not mentioned in said claims.

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SUBSTITUTE SHEET

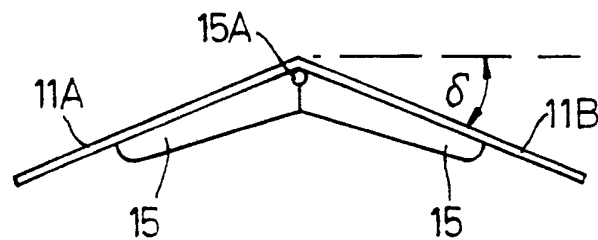
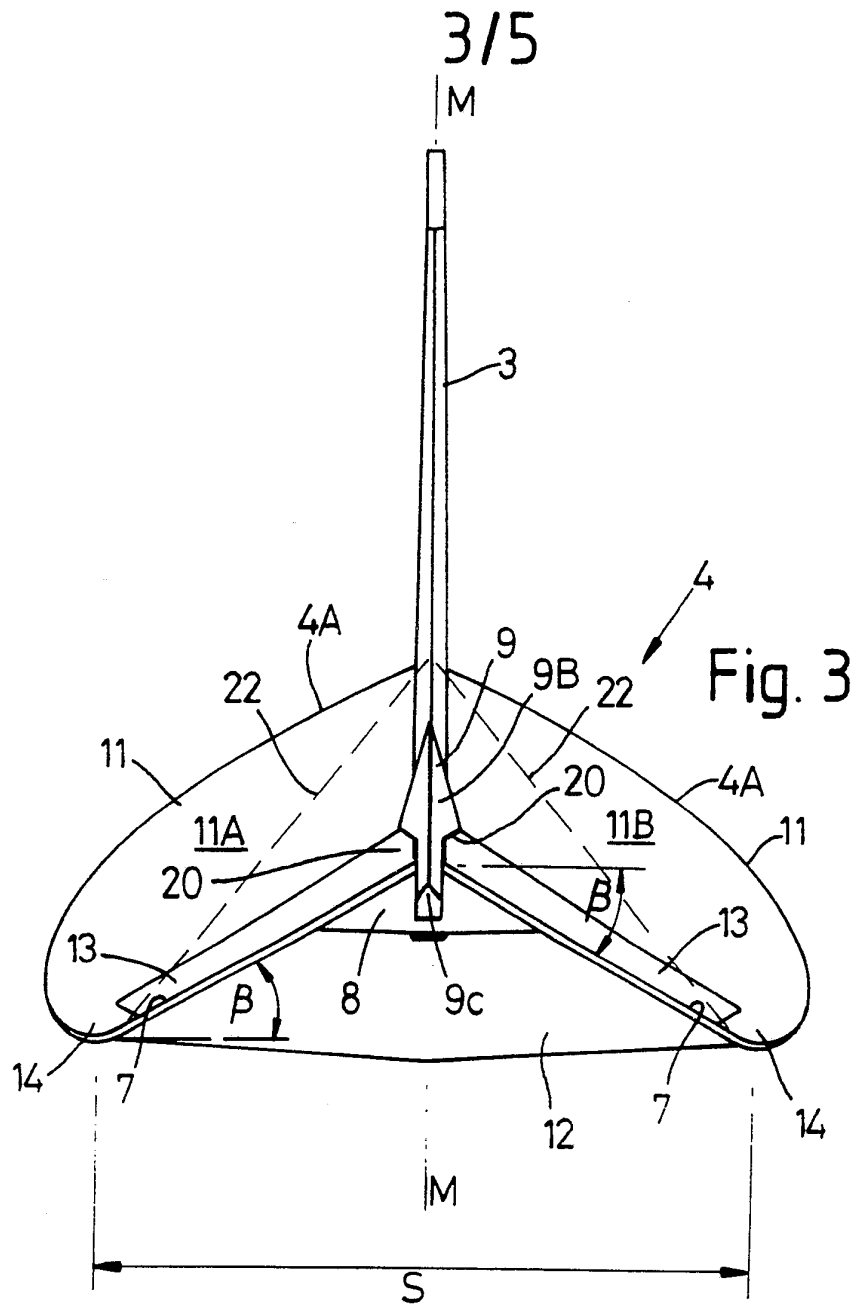


Fig. 6

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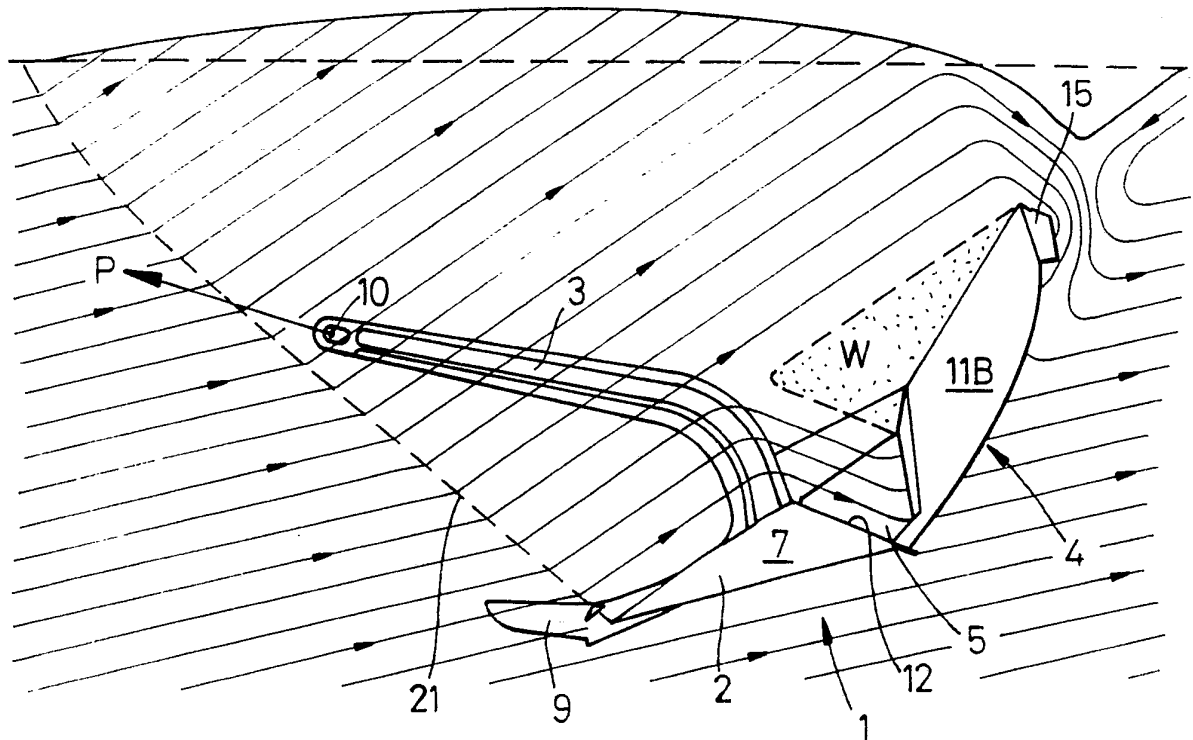


Fig. 8

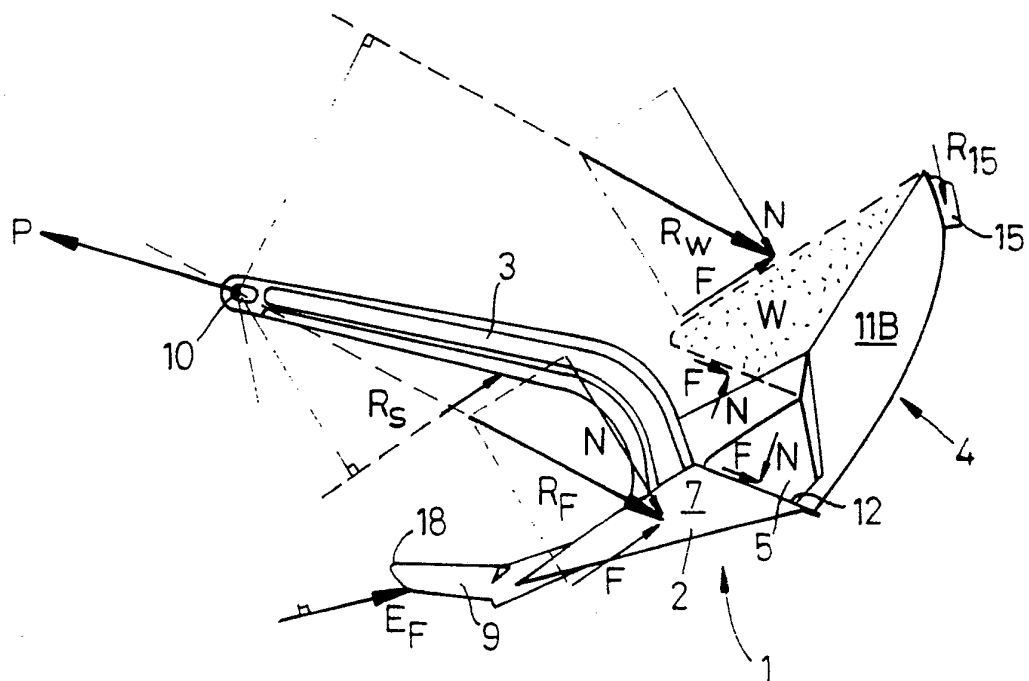


Fig. 9

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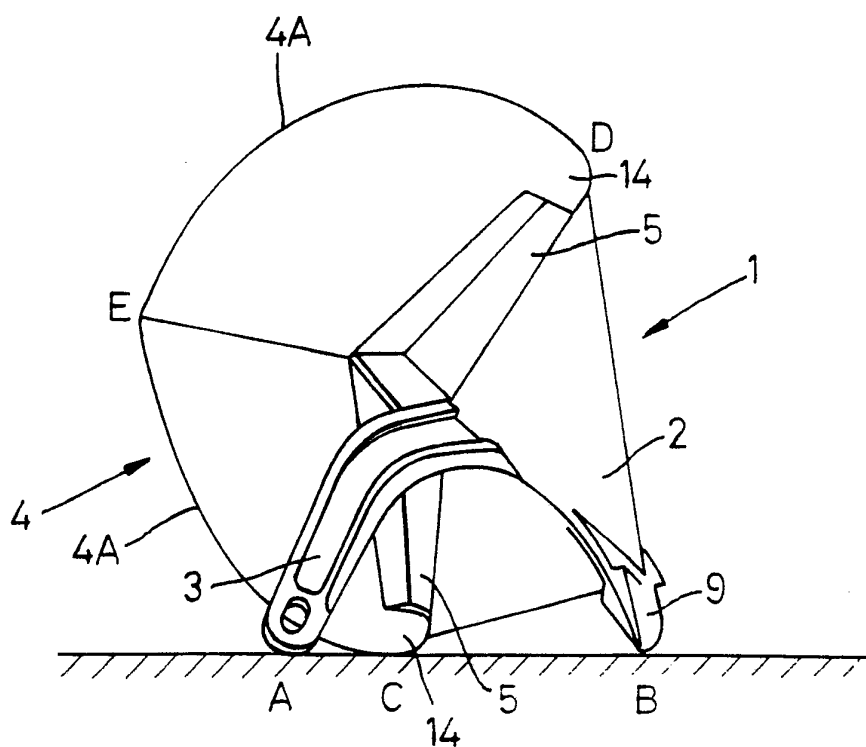
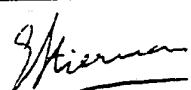


Fig. 10

INTERNATIONAL SEARCH REPORT

PCT/GB 92/00921

International Application No.

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC Int.Cl. 5 B63B21/32		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
Int.Cl. 5	B63B	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹		
Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
X	WO,A,8 505 084 (BRUPAT LTD.) 21 November 1985 see abstract; figures	1-5,8,9
X	& EP-A-180 609 cited in the application ---	
X	US,A,3 685 479 (P.BRUCE) 22 August 1972 see abstract; figures 1,2 ---	1-4
A	EP,A,0 196 801 (R.SMITH) 8 October 1986 see abstract; figures ---	8
A	EP,A,0 220 758 (R.VAN DEN HAAK) 6 May 1987 see page 4, line 25 - line 35; figures 1-3 ---	35
¹⁰ Special categories of cited documents :¹⁰ "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
07 JULY 1992	21. 07. 92	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	STIERMAN E.J. 	

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO. GB 9200921
SA 59494

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on
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