April 13, 1954 R. S. DANFORTH 2,674,968

MOORING ANCHOR

Filed Feb. 7, 1952 4 Sheets-Sheet 1

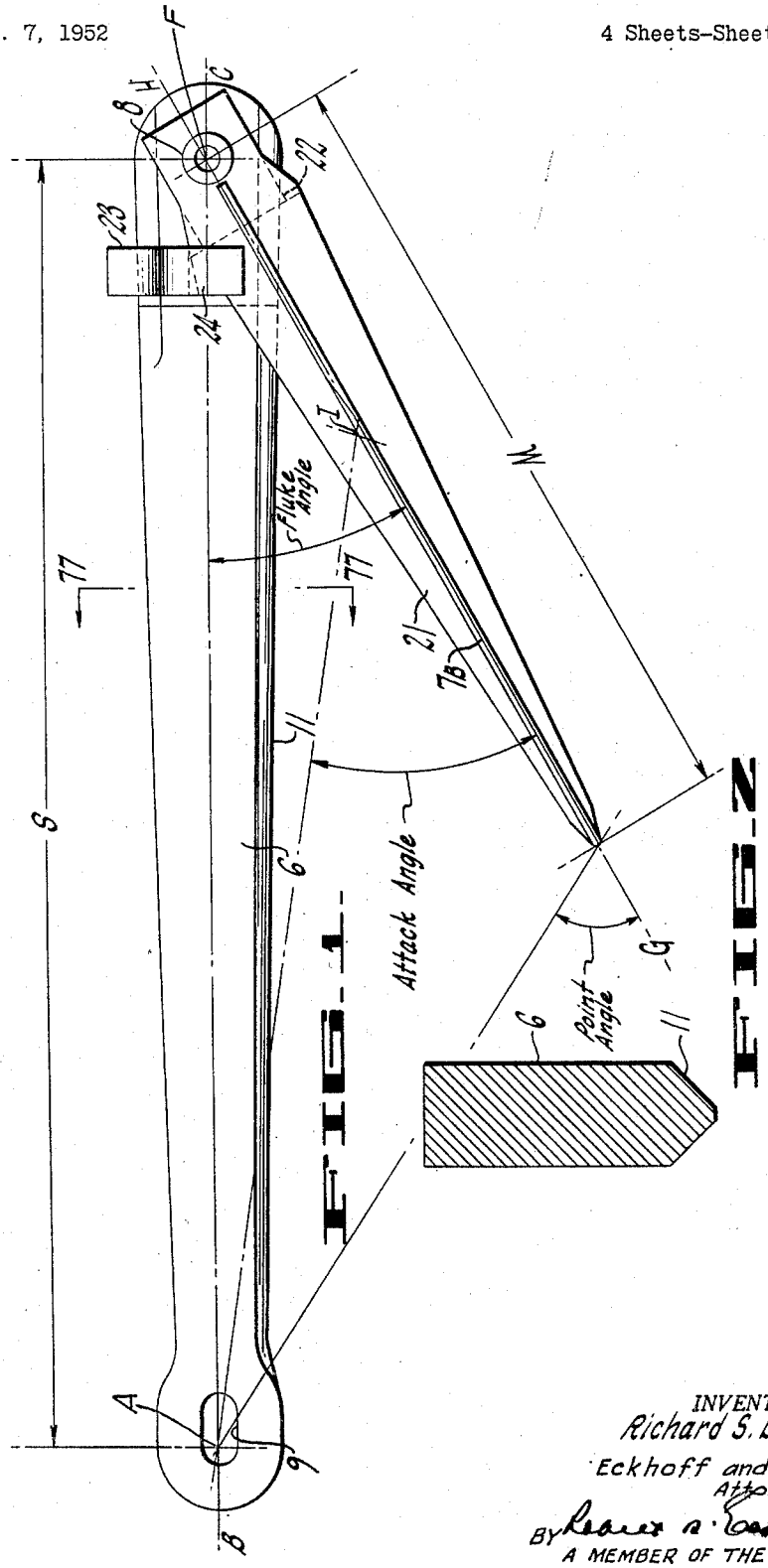


FIG. 1

FIG. 2

INVENTOR.
Richard S. Danforth
Eckhoff and Slick
Attorneys
BY Robert S. Eckhoff
A MEMBER OF THE FIRM

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MOORING ANCHOR

Filed Feb. 7, 1952 4 Sheets-Sheet 2

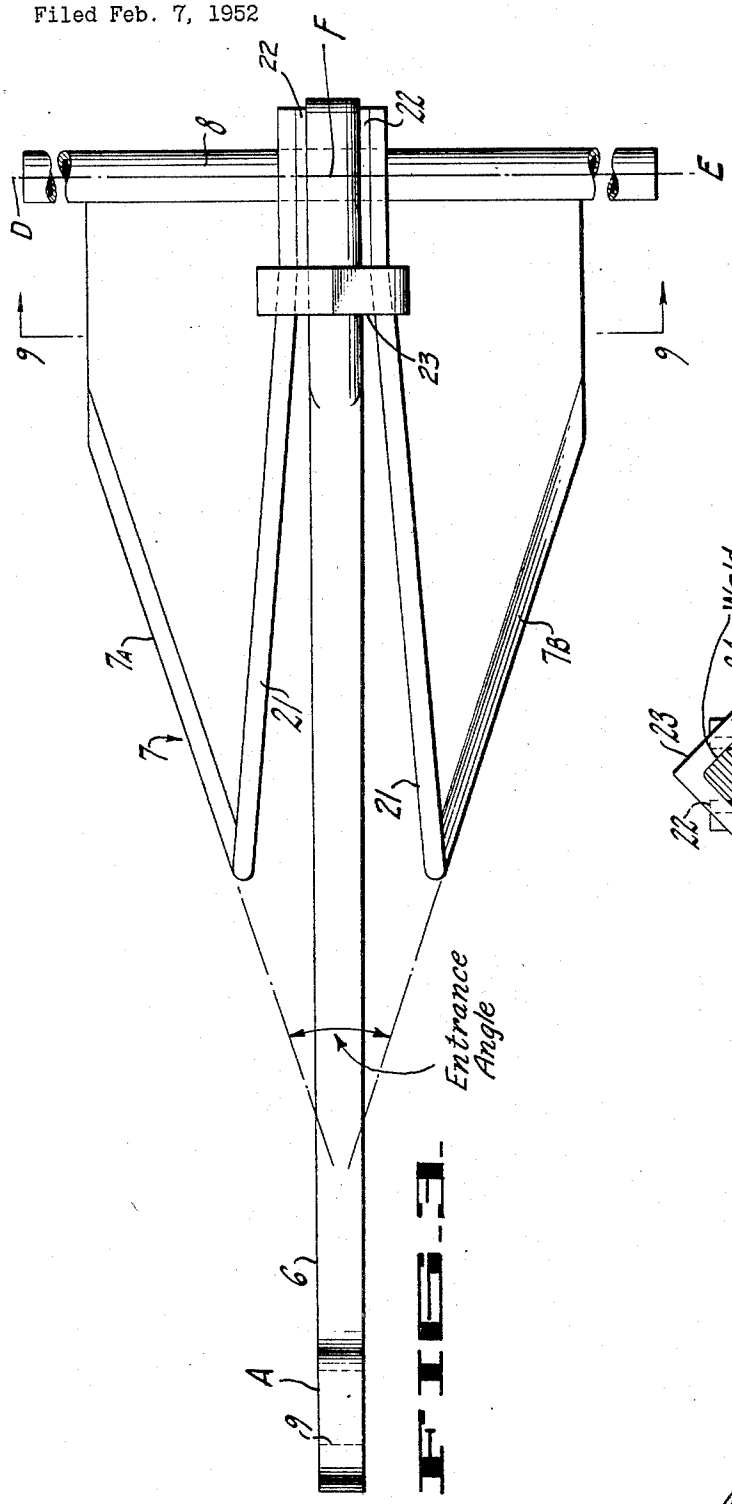


FIG. 3.

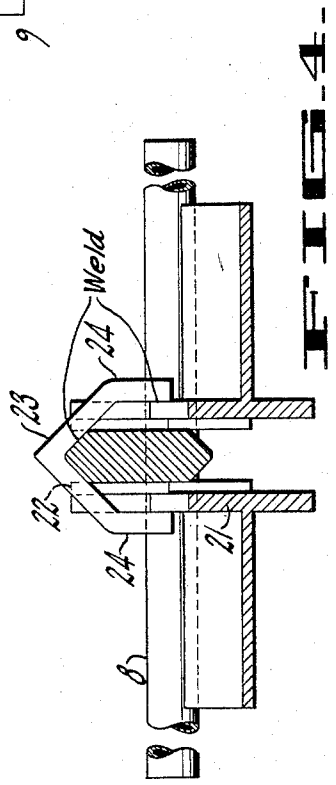


FIG. 4.

INVENTOR.
Richard S. Danforth
Eckhoff and Slick
Attorneys
BY Robert B. Benhoff.
A MEMBER OF THE FIRM

April 13, 1954 R. S. DANFORTH 2,674,968

MOORING ANCHOR

Filed Feb. 7, 1952 4 Sheets-Sheet 3

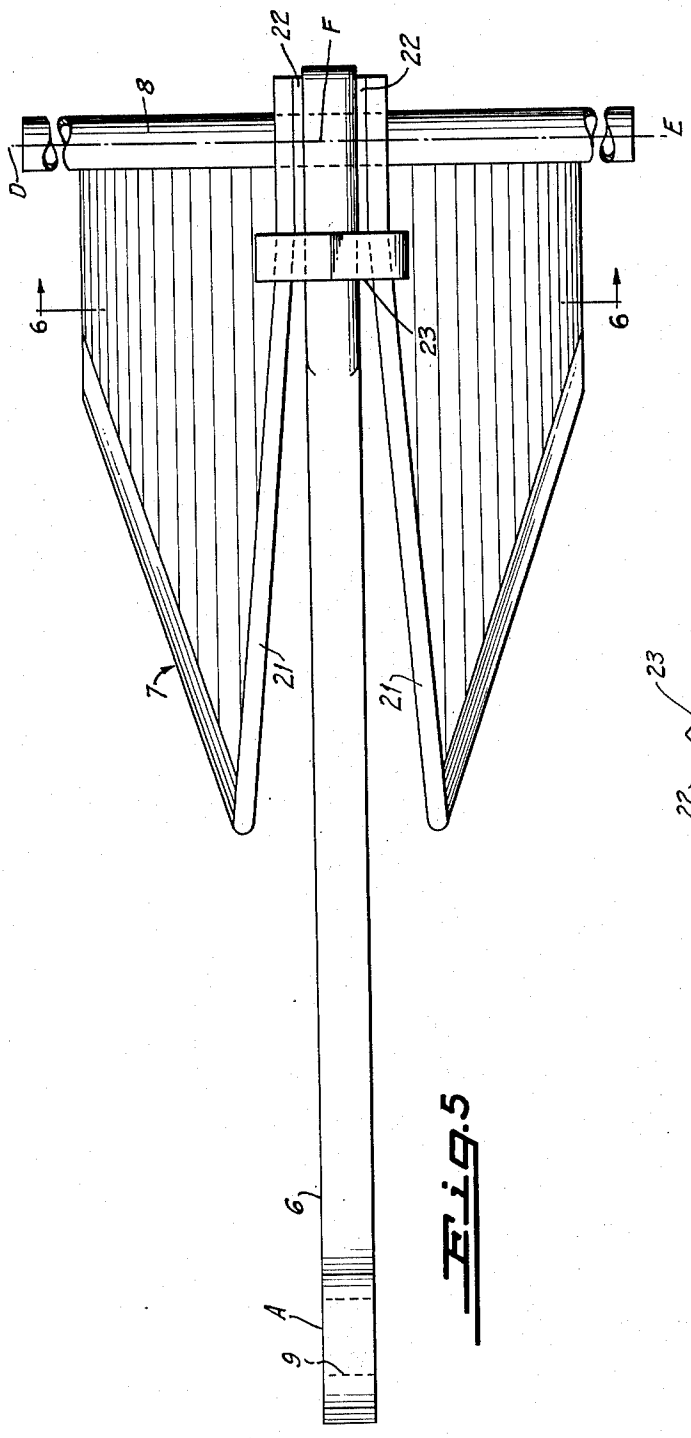


Fig. 5

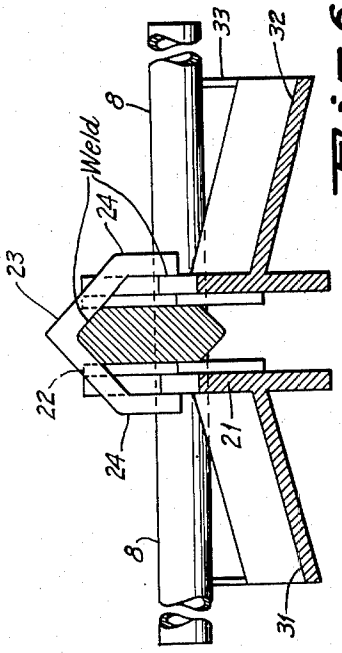


Fig. 6

INVENTOR.
Richard S. Danforth

ECKHOFF & SLICK
ATTORNEYS

BY Robert D. Seaman
A MEMBER OF THE FIRM

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MOORING ANCHOR

Filed Feb. 7, 1952 4 Sheets-Sheet 4

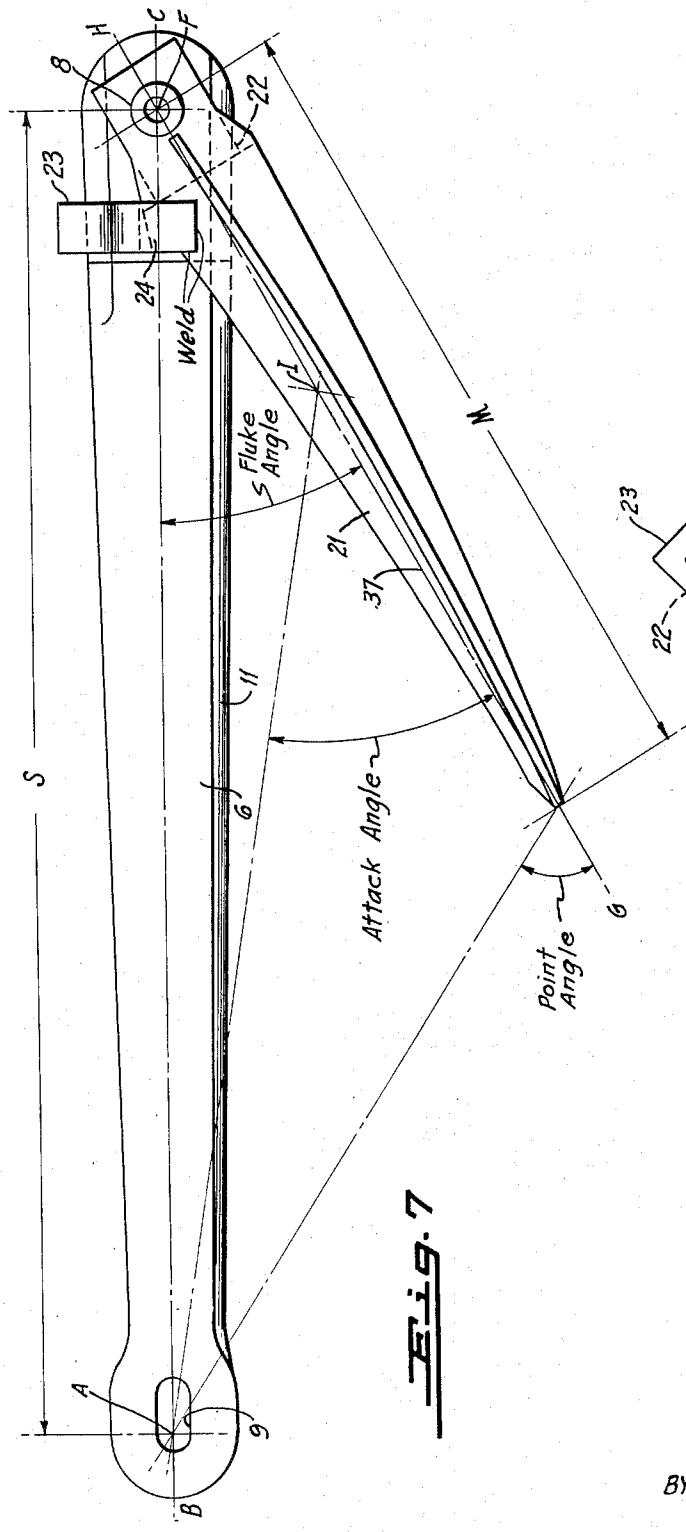


Fig. 7

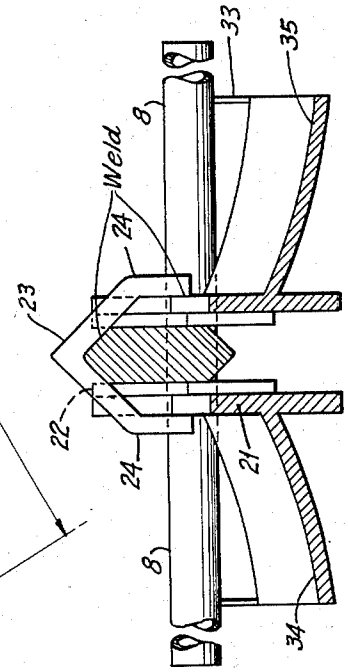


Fig. 8

INVENTOR.
Richard S. Danforth
ECKHOFF & SLICK
ATTORNEYS
BY Robert H Eckhoff
A MEMBER OF THE FIRM

Patented Apr. 13, 1954 2,674,968

UNITED STATES PATENT OFFICE

2,674,968

MOORING ANCHOR

Richard S. Danforth, Berkeley, Calif., assignor to Robert H. Eckhoff, Piedmont, Calif., as trustee

Application February 7, 1952, Serial No. 270,343

8 Claims. (Cl. 114—207)

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This invention relates to mooring anchors. This is a continuation-in-part of my application Serial No. 35,349, filed June 26, 1948, and which has since been formally abandoned, and of application Serial No. 156,182, filed April 15, 1950.

Generally, anchors can be divided into three major groups, the kedge or old fashioned stock anchor, the pivoting fluke or stockless anchor, and the mooring anchor. The kedge anchor includes a shank from one end of which projects two opposite extending curved arms carrying flukes or palms. The shank is provided with a long bar or rod providing a stock, the latter extending in a plane transverse to that of the fluke arms so that one arm and its palm engage bottom; the stock can be at either end of the shank.

The pivoting fluke anchor is that commonly used today on most merchant ships and by many navies because of the ease with which it can be drawn into a hawse pipe and held there ready for use. Its principal characteristic is that it includes a shank and twin flukes, usually secured together as a unit and pivoted at one end of the shank whereby the flukes simultaneously engage the ground. The pivoting fluke type anchor can have a stock at either end of the shank; in the commonest form of this anchor, the stock is omitted. It must also include a crown structure to cause initial engagement of the flukes, either by lifting the rear end, as in the Danforth anchor, or by rotating the flukes, as in the old style stockless anchor.

The mooring anchor is utilized to provide a mooring of a more or less permanent nature. Such a mooring usually includes one or more buoys connected to some means for engaging bottom with relatively great security and permanence. Permanent moorings are laid for numerous reasons, e. g., to ensure that a moored ship will not drag even in heavy weather; no ship relies on her anchors and cables without being able to move under her own power upon reasonably short notice and, for this reason, a permanent mooring must provide practically absolute security against dragging. Permanent moorings are also utilized to preserve ships' anchors and cables from wear and tear, to make use of limited space by providing berths suitable for all classes of ships using a port, and to facilitate port administration by enabling ships to come and go with a minimum of outside help with certainty of position to be taken. The actual ground engaging means utilized in a permanent mooring includes various forms of heavy

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weights and anchors which are placed in position and connected singly or in groups to one or more buoys which are engaged by a ship wishing to moor.

It has heretofore been proposed to utilize a mooring anchor which can be said to be of the kedge type in that the fluke is fixed relative to the shank and does not pivot. Such anchors have usually been made by cutting off an arm and its attached fluke from an ordinary kedge anchor. All mooring anchors known prior to this invention included a single fluke supported in a spaced relation to the shank by an arm.

The kedge anchor, the pivoting fluke anchor and the mooring anchor have entirely different modes of action. For example, a kedge anchor having a stock at the forward end of the shank will usually first engage bottom with one end of the stock and the two fluke arms touching bottom. As an anchor is pulled, it gradually tips over until the tip of one fluke engages bottom and the stock is approximately parallel with the bottom on which it rests. Upon further drag on the anchor, the tip of the fluke enters and the anchor buries to some extent. The usual kedge anchor will not bury deeply in hard ground, this being confined to the palm and part of the fluke arm, the rest of the anchor being above bottom. Although a great deal of research has been done, as shown by the thousands of issued patents throughout the world, there have been no radical improvements in this type of anchor for some two thousand years.

In a kedge anchor with the stock aft, the action differs in that the anchor rests initially upon one end of the stock, the tip of one fluke and the cable end of the shank. As the anchor is dragged, the fluke will immediately enter the ground and the anchor will gradually turn to a position where the stock is parallel or nearly so to bottom.

In the pivoting fluke types of anchor, the anchor will rest flat on the bottom if this will support the anchor; if the bottom is soft, the rear and heavier end of the anchor will be buried in the soft bottom while the flukes will be inclined upwardly from the surface of the bottom. The anchor has to be dragged for some distance before the flukes will turn and enter the bottom. It is necessary to provide an extensive and effective lifting or rotating mechanism at the after end of the anchor to start the flukes penetrating bottom. If the lifting or rotating action on the flukes is effective, the flukes will turn as the anchor is dragged along, and the anchor

will gradually penetrate bottom to some extent, depending on the design. It is usually necessary to drag a pivoting fluke type of anchor 15 to 20 feet before it develops any degree of holding power, while the lifting or rotating device at the rear of the anchor provides considerable resistance to deep burial.

I have discovered that the holding power of a mooring anchor can be increased greatly to provide an anchor capable of holding more than any anchor of any type if the mooring anchor embodies certain presently related structural relationships.

In use, the mooring anchor of this invention, when properly placed on bottom, is ready for instant use and is capable of providing substantial holding power immediately a pull is applied to its shank. Further, the mooring anchor of this invention is capable of such deep penetration into bottom that the anchor, in effect, becomes locked therein because the bottom is so dense that the anchor cannot penetrate further. This assures excellent holding in even the softest bottoms because the mooring anchor of this invention will continue to bury itself until it has come to rest in hard dense bottom and cannot go deeper. The advantages and value of this are manifest to any one desiring a reliable mooring.

It is in general a broad object of the present invention to provide an improved anchor especially suited for use as a mooring anchor.

Another object of the present invention is to provide an improved mooring anchor wherein relatively high holding power per pound of weight of the anchor is provided.

A further object of the present invention is to provide a mooring anchor having a shank, stock, and flukes, and wherein the area of the flukes is located in such relation to the point of cable attachment and bears such a relation to the resistance area as to ensure continued penetration of the anchor into bottom until the anchor is firmly seated in hard bottom.

An additional object of the invention is to provide a mooring anchor which can be manufactured easily and of relatively low priced materials, and which has high unit holding power so that the anchor provides very inexpensive mooring.

The invention includes other objects and features of advantage, some of which, together with the foregoing, will appear hereinafter when the present preferred form of mooring anchor of this invention is disclosed.

In the drawings,

Figure 1 is a side elevation of an anchor embodying the present invention.

Figure 2 is a section taken along the line 11—11 of Figure 1.

Figure 3 is a plan of the anchor shown in Figure 1, while Figure 4 is a section taken along the line 9—9 in Figure 3.

Figure 5 is a plan view of a modified form of anchor embodying the present invention.

Figure 6 is a section taken along the line 6—6 in Figure 5.

Figure 7 is a side elevation of another modified form of anchor, while Figure 8 is a section similar to Figure 6, but taken on the anchor shown in Figure 7.

Referring to the drawings, I have shown a structure including a shank 6 and having bifurcated and separate fluke elements or palms 7*a* and 7*b* provided on opposite sides of the shank. Each fluke includes a rib 21 extending along its inner edge joined along its rear edge to the stock 8. The stock 8 is shown at the rear of the flukes, extending through a suitable aperture in the shank and providing additional support and attachment for the flukes and shank; the stock can, however, be at the forward end of the shank. The anchor can be made of cast or forged parts or of those cut from plate or other structural elements.

Spacer plates 22 are provided between each rib and the rear end of the shank, the ribs, spacer plates and shank being joined together as by welding. To provide additional securing of the flukes with respect to the shank, a V-shaped member 23 is fitted over the upstanding portion of the shank and legs 24 thereon are joined to each of the ribs although such reinforcement is not essential and the flukes, stock and shank can be joined as only by welding. By providing separate twin flukes the holding power of the mooring anchor can be considerably increased but one can unite the twin flukes and utilize a single fluke extending on opposite sides of the shank.

The shape of the flukes should be such as to enable it to engage bottom quickly and to penetrate bottom readily. To this end, each fluke should have as relatively sharp a point as is feasible; in addition, the shape should be such as to offer as little resistance to penetration as is consistent with the other desired anchor characteristics. I have found that if one provides the fluke structure with each fluke of such shape that it has an entrance angle of between 17½° and 27½°, preferably about 22½°, then the fluke will have the desired characteristics in this respect. The entrance angle is measured by laying out a triangle approximating the shape of the forward portion of the fluke, such triangle containing only about 40% of the total area of the fluke; the entrance angle is then the angle between the two sides which extend rearwardly from the apex of the triangle, the latter corresponding approximately to the point of the fluke. Since the outer edge of the fluke can be straight or curved or can be various combinations of straight and/or curved portions, resort must be had to an approximation of this nature to care for the various shapes which can be employed. When a single fluke is provided, the entrance angle values are the sum of values given, e. g., between 35° and 55°, and preferably about 45°.

For the purposes of discussion and to enable the various essential dimensional and proportional relations to be readily understood, the following additional definitions and dimensions are employed in defining the mooring anchor of this invention.

A is the point of cable attachment at the forward end of the shank.

Line BC is the axis of the shank and line DE is the axis of the stock; the two lines intersect, when the stock is at the rear of the anchor, at point F. The line GH lies in a plane substantially parallel to the forward or advancing face of the fluke. The point I is the center of area of the fluke faces; this point can be determined by application of usual and known geometric methods to those portions of the fluke faces which provide the effective holding power of the anchor, it being unnecessary to take into account small fluke areas which, while possibly part of a fluke, contribute little if anything to the anchor holding power and which otherwise make the ascer-

tainment of the center of area of the entire fluke forward faces relatively difficult.

The effective shank length is the distance from the point A of cable attachment to the line DE, the axis of the stock, when this is provided at the rear of the anchor; it is indicated as dimension S and is referred to as the shank length. The measurement M is the length of the flukes and is the distance between the points of the flukes and the rearward effective edge thereof; in the form shown in the drawing the rearward effective edge on the flukes is substantially coincident with the stock axis DE.

The stock length is the overall length on the axis DE.

The fluke angle, as indicated in Figure 1, is the angle between the axis BC of the shank and a plane GH, substantially parallel to the fluke forward face.

The attack angle, as indicated on Figure 1, is the angle between projected plane GH and a line passed through the point of cable attachment A and the areal center I of the effective fluke forward faces.

The point angle, as indicated on Figure 1, is the angle between projected plane GH and a line passed through the point of cable attachment A and the point of the flukes.

The "resistance area" is the total area of the anchor projected parallel to the fluke axis and onto a plane normal to such axis; such a plane is normal to the plane GH.

The fluke area is that portion of the forward face of the flukes which is effective to provide holding power in bottom engagement; in the form of anchor shown it comprises the entire area of the flukes. If the flukes are curved or are angularly formed along their longitudinal axis, their transverse axis or both, the fluke area is best measured by projecting the forward faces onto a plane which is tangent or substantially so, to the fluke faces at the center of area so that, in effect, the fluke faces are reduced to planar form. This approximation is desirable because otherwise one cannot compare the various elements and characteristics.

The shackle distance is the distance AI in Figure 1 between the point of cable attachment A and the areal center I of the fluke area.

In the preferred form of anchor shown in the drawing, the fluke portions on each side of the shank are in the same plane. While this construction is preferred because it enables the several components to be cut, shaped and welded together rapidly at low cost and from inexpensive materials, it is possible to fashion the fluke with the opposite fluke portions at a dihedral angle up to 15° and even higher, as is shown in Figures 5 and 6, wherein the flukes **31** and **32** are shown at a dihedral angle of 15°. A spacer **33** is provided between the ends of the flukes and the stock **8** to secure the rear ends of the flukes in place. It is also obviously possible to make the fluke, or at least some portion thereof, arcuate in transverse section as has been indicated in Figure 8 wherein flukes **34** and **35** are shown as being arcuate in transverse section. In this same connection, it must be pointed out that the fluke can be made with at least some portion of it in arcuate form along the longitudinal axis as well as the transverse axis, as is shown in Figure 7, wherein the flukes **37** are shown as having an arcuate form along their longitudinal axis. The effect of such variations on the operational characteristics and values is generally only slight at the most. In applying the teachings of the present invention to anchors wherein such arcuate or angular modifications are introduced, one should generally make an approximation on the basis of an equivalent plane surface or straight line, as the case may require, and then apply the teachings, just as if the surface or line was flat or straight. The values given in this respect of the various characteristics are based on the use of plane surfaces and straight lines.

To ensure maximum performance, the several elements of the anchor should have certain relations to one another, as follows:

The relation of the fluke area to the shackle distance is of importance inasmuch as it is this relation which defines the relative position of the point of application of the force tending to pull the anchor into bottom and the center of area of the fluke. Since one is comparing a lineal dimension with an area, one should, for reasons of comparison on an equal basis, deal with the square of the shackle distance. This ratio is referred to hereinafter for brevity as the "fluke area-shackle distance ratio." Comparing the fluke area to the square of the shackle distance, the ratio should be greater than 0.13 and even as much as 0.16 to 0.18.

The resistance area to the shackle distance is also of importance. Again, since one is comparing an area to a lineal dimension, the square of the distance is employed. The resistance area should be less than 0.2 the square of the shackle distance and preferably less than 0.1, consistent with adequate structural strength. This ratio will vary somewhat with the size of the anchor because a larger anchor will require a larger mass of metal to provide the same relative strength. In the following table this variation is shown for anchors of different weights, the several anchors being made of the same material, in the same design and with the same strength:

Weight of anchor, pounds	3–99	100–999	1,000–9,999	10,000–20,000
Ratio	.093	0.13	0.18	0.20

In addition to the foregoing, the mooring anchor should have a stock adequate to prevent rotation and to insure that the anchor initially rests on the end of the stock, a point of one of the flukes and an end of the shank; the stock should be from 75% to 85%, preferably 95% or more of the shank length. The stock can be at either end of the shank, although it is preferable to have it at the after end of the shank.

To ensure easy penetration, the anchor should have an attack angle, as previously defined, of from 25° to 55°, preferably one in the range of 30°–50° and even more desirably between 33° and 48°.

The point angle should also be between 50°–80° and preferably between 53° and 78°, and even more, preferably between 56° and 75°.

The fluke angle is not too important; it is usually fixed by other factors and in and of itself it is not a vital determinant; if it is in the range of 25° to 39° and preferably 28° to 36°, conditions are usually satisfied; the preferred angle is of a value of 30° for cast steel anchors and 34½° for anchors made of plate and structural steel.

Anchors of this design have been proved in tests by government authorities to have from

seven to ten times the holding power of mooring anchors previously used.

I claim:

1. An anchor consisting solely of a shank having a forward and an after end, cable attachment means at the forward end of the shank, a stock extending normal to the shank at the after end of the shank, and a pair of flukes disposed symmetrically on each side of said shank, each fluke being a thin flat plate extending fixedly forward from a junction with the stock at an angle to the shank of from about 25° to about 39°, the outer edges of each fluke providing an entrance angle, as herein defined, of from about 17½° to about 27½°, said flukes each having a sharp terminal end at their forward end, the flukes having their rear terminal ends secured to the stock on each side of the shank, the ratio of the area of said flukes to the square of the shackle distance, as shackle distance is herein defined, being greater than 0.16, the stock having a length of at least 75% of the length of the shank, the anchor having an attack angle, as herein defined, of between 25° and 55°.

2. An anchor consisting solely of a shank having a forward and an after end, cable attachment means at the forward end of the shank, a stock extending normal to the shank at the after end of the shank, and a pair of flukes disposed symmetrically on each side of said shank, each fluke being a thin flat plate of generally triangular shape and extending fixedly forward from a junction with the stock at an angle to the shank of from about 25° to about 39°, the outer edges of said flukes being at an angle to one another and defining a sharp terminal forward end, the flukes having their rear terminal ends secured to the stock on each side of the shank, the ratio of the area of said flukes to the square of the shackle distance, as shackle distance is herein defined, being greater than 0.13, the stock having a length of at least 75% of the length of the shank, the anchor having an attack angle, as herein defined, of between 25° and 55°.

3. An anchor consisting solely of a shank having a forward and an after end, cable attachment means at the forward end of the shank, a stock extending normal to the shank at the after end of the shank, and a pair of flukes disposed symmetrically on each side of said shank, each fluke extending fixedly forward in a single plane from a junction with the stock at an angle to the shank, the outer edges of said flukes defining a sharp terminal end, the flukes having their rear terminal ends secured to the stock on each side of the shank, the ratio of the area of said flukes to the square of the shackle distance, as shackle distance is herein defined, being greater than 0.13, the stock having a length of at least 75% of the length of the shank, the anchor having an attack angle, as herein defined, of between 25° and 55°.

4. An anchor consisting solely of a shank having a forward and an after end, cable attachment means at the forward end of the shank, a stock extending normal to the shank at the after end of the shank, and a pair of flukes disposed symmetrically on each side of said shank, each fluke being a thin flat plate triangularly shaped and extending fixedly forward from its junction with the stock at an angle to the shank of from about 28° to about 36°, the outer edges of said flukes providing an entrance angle, as herein defined, of about 22½°, said flukes each having a sharp terminal end, the flukes having their rear terminal ends secured to the stock on each side of the shank, the ratio of the area of said flukes to the square of the shackle distance, as shackle distance is herein defined, being greater than 0.16, the stock having a length of at least 85% of the length of the shank, the anchor having an attack angle, as herein defined, of between 30° and 50°.

5. A fixed fluke anchor including the following structural elements: a shank having a forward and an after end; a stock connected to and extending normal to the shank at one of said ends thereof; cable attachment means at the forward end of the shank; the shank and stock defining a common plane; and a pair of flukes disposed symmetrically with respect to the shank and secured in a position of fixed angular relationship at the after end of the shank; said flukes each having a terminal end and being disposed on opposite sides of the shank; each of said flukes extending forwardly from its connection with the shank in approximately a single plane with its rear edge substantially intersecting the common plane of the stock and the shank at the after end of the shank; the rear end of the flukes and of the shank being substantially free of any protuberances at their juncture, whereby the anchor has a minimum of resistance to burial; the fluke area to shackle distance ratio, as herein defined, being greater than 0.16; and a resistance area to shackle distance ratio, as herein defined, being less than about 0.20.

6. A fixed fluke anchor including the following structural elements: a shank having a forward and an after end; a stock connected to and extending normal to the shank at one of said ends thereof; cable attachment means at the forward end of the shank; the shank and stock defining a common plane; and a pair of flukes disposed symmetrically with respect to the shank and secured in a position of fixed angular relationship at the after end of the shank; said flukes each having a terminal end and being disposed on opposite sides of the shank; each of said flukes extending forwardly from its connection with the shank in approximately a single plane with its rear edge substantially intersecting the common plane of the stock and shank at the after end of the shank; the rear end of the flukes and of the shank being substantially free of any protuberances at their juncture, whereby the anchor has a minimum of resistance to burial; the fluke area to shackle distance ratio, as herein defined, being greater than 0.13; the resistance area to shackle distance ratio, as herein defined, being less than about 0.20; and the attack angle, as herein defined, being from 25° to 55°.

7. A fixed fluke anchor including the following structural elements: a shank having a forward and an after end; a stock connected to and extending normal to the shank at one of said ends thereof; cable attachment means at the forward end of the shank; the shank and stock defining a common plane; and a pair of flukes disposed symmetrically with respect to the shank and secured in a position of fixed angular relationship at the after end of the shank; said flukes each having a terminal end and being disposed on opposite sides of the shank; each of said flukes extending forwardly from its connection with the shank in approximately a single plane with its rear edge substantially intersecting the common plane of the stock and shank at the after end of the shank; the rear end of the flukes and of the shank being sub-

stantially free of any protuberances at their juncture, whereby the anchor has a minimum of resistance to burial; the fluke area to shackle distance ratio, as herein defined, being greater than 0.13; the resistance area to shackle distance ratio, as herein defined, being less than about 0.20; and the point angle, as herein defined, being from 50° to 80°.

8. A fixed fluke anchor including the following structural elements: a shank having a forward and an after end; a stock connected to and extending normal to the shank at one of said ends thereof; cable attachment means at the forward end of the shank; the shank and stock defining a common plane; and a pair of flukes disposed symmetrically with respect to the shank and secured in a position of fixed angular relationship at the after end of the shank; said flukes each having a terminal end and being disposed on opposite sides of the shank; each of said flukes extending forwardly from its connection with the shank in approximately a single plane with its rear edge substantially intersecting the common plane of the stock and shank at the after end of the shank; the rear end of the flukes and of the shank being substantially free of any protuberances at their juncture, whereby the anchor has a minimum of resistance to burial; the ratio of the area of said flukes to the square of the shackle distance, as herein defined, being at least 0.13; the ratio of the resistance area to the square of the shackle distance, as herein defined, being less than about 0.20; the stock having a length of at least 75% of the length of the shank; and the anchor having an attack angle, as herein defined, of between 25° and 55°.

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