The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates generally to subterranean anchors for supporting walls, piles, and the like, and particularly to umbrella type anchors having arms adapted to be expanded underground to provide tension or bearing supports for corresponding loads.

In some harbor installations, employment of anchors and piles in a normal manner is either impractical or unduly expensive. Dragging of ordinary anchors during ship liberations, or derricking, may be objectionable, hazardous, and unacceptable, particularly in crowded anchorages; space restrictions may prohibit placement of spread-type moorings; or the bedrock may be too deep to provide bearing support for conventional bearing or stake piles or too shallow to permit sufficient embedment.

The principal object of this invention, therefore, is to provide an umbrella pile anchor that can be successfully used as either an anchor for moorings or utilized as a pile in locations where standard pilings either could not be used or would be uneconomical for such use.

Other objects, advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings wherein:

FIGURE 1 is an elevation, partly in cross-section, illustrating the invention in its assembled form;

FIG. 2 is an elevation, partly in cross-section, illustrating significant portions of the invention embedded in a subterranean environment;

FIG. 3 is a top plan view of the invention as shown in FIG. 1;

FIG. 4 is a bottom view of the invention;

FIG. 5 is an enlarged elevation in cross-section, illustrating the main working portions of the invention;

FIG. 6 is a cross-sectional view taken on the line 6-6 of FIG. 5;

FIG. 7 is a view taken on line 7-7 of FIG. 5 illustrating a detail of the invention;

FIG. 8 is an elevation of the main working portions of the invention in an extended or working position;

FIG. 9 is a cross-section taken on the line 9-9 of FIG. 1;

FIG. 10 is a cross-section taken on the line 10-10 of FIG. 1.

With reference to FIG. 1, the umbrella pile-anchor comprises casing 21, follower tube 25, tubular frame 28, and toe plates 32. Tubular casing 21 is provided with lifting slots 22 which may be welded or otherwise suitably secured thereto, and four external peripheral grooves 23 of sufficient length to house certain portions of the umbrella structure 35 as will be more detailed hereinafter. As indicated on FIG. 4, these grooves 23 may be formed by cutting slots 24 of sufficient length in the lower end of the casing and then covering these slots with the formed members 23 which may be welded or otherwise suitably secured to the external walls of the casing. Casing 21 is supplied with a slot 26 in its upper portion for allowing chain 27 to protrude from the assembly below the driving tops of the casing and the follower tube 25. The latter is provided with a corresponding slot 29 for a similar purpose.

With reference to all of the figures, follower tube 25 is fitted with a lower extension 30 which may be welded or suitably secured thereto. This lower extension 30 is adapted to fit over the upper end of tubular frame 28. Normally follower tube 25 and tubular frame 28 will be of the same external diameter. Frame 28 is provided at its lower end with a frame base 31 which is welded thereto. Frame base 31 is provided with a central aperture 33 which is positioned concentric with the longitudinal axis of the frame 28. A frame spacer 36 is then welded in place to and below frame base 31. As will be noted from FIG. 6, this frame spacer 36 is constructed in four parts. Each part consists of a quadrant segment 37 to which is welded a longitudinal stiffener 38. While clearly shown in FIGS. 6 and 8, these stiffeners have been omitted from FIGS. 2 and 5 for purposes of clarity. As will be obvious, frame spacer 36 is constructed by taking a length of suitable tubing, welding the longitudinal stiffeners thereto at four equally spaced points around the periphery of the tubing and then making four longitudinal cuts at points equidistant from the stiffeners. When welded to their respective base frame base 31 and space plate base 39, these quadrant segments 37 are so positioned as to leave slots 40. Spacer base plate 39 is welded concentrically with the longitudinal axis of the frame spacer 36 and is provided on its lower side with a plurality of spaced lugs or padeyes 41. These lugs 41 are provided as points of attachment for the flukes 50 as will be described later.

Concentric to tubular frame 28 and protruding through the central aperture 33 in frame base plate 31 is mounted runner 42. Chain link or shackle 43 is secured to the upper end of runner 42 for connecting the runner to the chain 27. At the lower end of runner 42, arms 44 are provided which are welded to the bottom section of the runner. These arms 44 are equally spaced around the periphery of the runner and protrude through the slots 40 in the frame spacer 36. These arms 44 are provided with pins 45 so that bracing arms 55 may be attached thereto. It will be noted here that the travel of runner 42 is limited by the distance between frame base plate 31 and spacer base plate 39.

The umbrella structure 35 comprises generally runner 42 with its arms 44, spacer base plate 39 with its lugs or padeyes 41, flukes 50 which are pivoted on the lugs 41, and bracing arms 55 which are pivotally connected to arms 44 and flukes 50.

Flukes 50 are a composite structure consisting of an upper planar portion 51, a centrally disposed stiffening rib 52 welded to the underside of planar portion 51, a pair of padeyes 53 welded on the upper end of the fluke for attachment to the lugs 41, a padeye 54 for the pivotal attachment of bracing arm 55 to the planar portion 51 of the fluke 50, and a toe 56.

Toe plate 32 is a composite structure consisting of a heavy bottom plate 60 having a radial extension 61 adapted to fit closely below the groove 23 of casing 21. Essentially, these bottom plates 60 are generally quadrant segments of an annulus having a peripheral diameter approximately equal to the outer diameter of the casing 21 and an internal diameter approximately two-thirds of the peripheral diameter. On top of the radial extension 61, a lug 62 is welded. This lug 62 engages the inside wall of the casing 21 at groove 23 and keeps the toe plates in place and prevents the casing from the initial driving operation. A pair of upwardly extending, symmetrically formed, angular plates 63 are then welded adjacent the inner circular portion of the bottom plate 60. A centrally disposed gusset plate 64 is then welded along the upper angular joint of these angular plates 63 which, in turn, is then welded to the fluke parts 51 and 52. Thus, the toe plates 32 are rigidly
secured to the ends of the flukes 50 and by being fixed over the end of casing 21 during the initial driving operation, these comparatively massive bottom plates not only close-off the end of the driving casing 21 against the entry of soil and muck, but also adequately protect the comparatively frail and vulnerable driving end of the casing. Also, as will be pointed out in more detail later, the inwardly and upwardly extending angular plates 63 facilitate the opening of the umbrella flukes to their designed limit.

In the operation of the device, FIG. 1 illustrates the umbrella pile in its initial driving configuration after having been driven to its designed depth in the ocean bottom 70. FIG. 2 illustrates the removal of the casing 21 and preparation to continue driving on the follower tube 25. As the driving commences, the inwardly inclined surfaces of angular plates 63 commence forcing the flukes outwardly. As the driving continues, the soil underneath the rig bears on the underside of the flukes which continues and augments the outward thrust of the flukes and toe plates. FIG. 5 illustrates the position of the flukes in approximately their half-open position. Arms 44 have now applied half of their travel between the plates 31 and 39. Where an exact knowledge of the fluke positioning is desirable, an indicator 71, as shown in FIG. 2, may be provided. This may be a simple tension spring and cable system between the top of the follower tube 25 and the upwardly movable arm 44 wherein the length of the spring indicates the movement of the arm 44 and hence the opening of the flukes 50 or it may be more sophisticated, including markers or other suitable indicating devices.

With the continuation of the driving force, the frame 28 is driven lower into the soil and the flukes open fully as shown in FIG. 8. Here the follower tube has been removed and the umbrella anchor is in position for use as a mooring anchor.

In the practical use and operation of the invention, selected lengths of casings and follower tubes are obtained depending on the depth to which the umbrella anchors are to be driven. The umbrella anchor and follower tube are then assembled in the casing with the latter resting on the fluke toe plates, the slots in the casing and follower tube aligned and the upper end of the chain placed in the slots out of the way of the hammer. The device is then lifted by the casing lifting ears and placed in position for driving. Some slack is left in the chain so as to later permit the inner assembly to drop a foot or two. The entire assembly is then driven to a depth somewhat less than that desired for the anchor when the flukes are in open position. Driving is then continued on the follower tube alone until the inner assembly is driven to the extent of the slack chain. At this point, the inner assembly is free of the casing and the latter may be removed after lifting the chain out of the slots and holding it in a vertical position.

Upon removal of the casing, the chain is returned to its follower tube slot and driving is continued. When the desired depth is reached, an indicator by the indicator or otherwise measured, and the flukes are fully opened, the chain is removed from its slot and the follower tube removed. The chain may then be secured to the mooring apparatus.

When it is desired to use the invention as a bearing pile, the driving is continued, as above, until the flukes are in their full open position. The chain is then held in a vertical position and the follower tube and tubular frame 28 are filled with concrete. After the concrete hardens, the follower tube becomes an integral part of the pile and the entire assembly may be placed in service for bearing or resistance to uplift. Excess chain extending above the top of the follower tube may be removed as desired.

Having thus described our invention, we claim:
1. An umbrella pile anchor comprising, in combination: an outer protective driving casing; an umbrella anchor assembly mounted within the lower portion of said driving casing, said anchor assembly having means cooperating with said casing to seal off the driven end of said casing against the entry of soil and muck while said casing is being driven; an inner driving follower tube concentrically located within said casing, said follower tube being adapted to drive said anchor assembly downwardly clear of the driven end of said casing; a hollow frame concentrically mounted within said casing and adapted to be driven by said inner driving follower tube; a frame base plate secured transversely of the lower end of said frame, said frame base plate having a central aperture therein; a hollow spacer secured to the lower side of said frame base plate, said spacer being in axial alignment with said frame and said spacer being provided with a plurality of longitudinal slots in its walls; a spacer base plate secured transversely of the lower end of said spacer; a plurality of expandable flukes pivoted to the lower surface of said spacer base plate; a movable runner concentrically located in said frame and said spacer, said runner having a shank passing through said central aperture in said frame base plate, a connection for a mooring chain at the upper end of said shank, and a plurality of arms at the lower end of said shank, said arms protruding outwardly through said slots in said spacer; and a plurality of pivoted bracing arms pivotally connecting said flukes with said runner.
2. An umbrella pile anchor comprising: an outer protective driving casing; an umbrella anchor assembly mounted within the lower portion of said driving casing; means, located within said casing, for driving the anchor assembly downwardly clear of the driven end of said casing; said umbrella anchor assembly having a base plate and a plurality of flukes pivoted at their upper ends to said base plate so as to be outwardly expandable; each of said flukes having a toe plate at its bottom end; each of said toe plates including a bottom plate which is substantially a quadrantal segment of an annulus having a peripheral diameter approximately equal to the diameter of the driven end of the casing and an upwardly extending plate connected adjacent the inner perimeter of each bottom plate, said toe plates being engageable with one another to seal off the bottom opening of the casing and said upwardly extending plate of each toe plate further being operable to initiate expansion of the flukes when the anchor assembly is driven clear of the driven end of the casing.
3. An umbrella pile anchor as claimed in claim 2 wherein said umbrella anchor assembly has means to limit the expansion of said flukes; and indicator means for indicating the extent of expansion of said flukes.
4. An umbrella pile anchor comprising: an outer protective driving casing; an umbrella anchor assembly enclosed within the lower portion of said driving casing; means connected to the anchor assembly and located within said driving casing for driving the anchor assembly downwardly clear of the driven end of the casing; said anchor assembly having a plurality of outwardly expandable flukes; and said flukes having toe plates which are engageable with one another to seal off the driven end of the casing.
5. An umbrella pile anchor comprising, in combination;
an outer protective driving casing;
an umbrella anchor assembly mounted within the lower portion of said driving casing, said anchor assembly having means cooperating with said casing to seal off the driven end of said casing against the entry of silt and soil while said casing is being driven;
an inner driving follower tube concentrically located within said casing, said follower tube being adapted to drive said anchor assembly downwardly clear of the driven end of said casing;
said umbrella anchor assembly incorporating a plurality of expandable flukes, said flukes being adapted to expand solely by the driving forces transmitted thereto by said inner driving follower tube;
said flukes being fitted with massive toe plates at the driven end thereof, said toe plates being adapted to seal off the driven end of said casing during the initial driving operation; and
each of said toe plates having an upwardly curved portion to initiate the expansion of said flukes when said anchor assembly is driven clear of the driven end of said casing.

6. An umbrella pile anchor comprising:
said umbrella anchor assembly as claimed in claim 5 wherein:
said umbrella anchor assembly has means to limit the expansion of said flukes; and
indicator means for indicating the extent of expansion said flukes.

7. An umbrella pile anchor comprising, in combination:
an outer protective driving casing;
an umbrella anchor assembly mounted within the lower portion of said driving casing, said anchor assembly having means cooperating with said casing to seal off the driven end of said casing against the entry of silt and soil while said casing is being driven;
an inner driving follower tube concentrically located within said casing, said follower tube being adapted to drive said anchor assembly downwardly clear of the driven end of said casing;
a frame initially concentrically located in said casing, said frame being adapted to be driven by said inner driving follower tube;
a lower base plate secured transversely of said frame;
a plurality of expandable flukes; and
means pivoting the upper ends of said flukes to said lower base plate.

8. An umbrella pile anchor comprising:
an outer protective driving casing;
an umbrella anchor assembly enclosed within the lower portion of said driving casing;
means located within said driving casing for driving the anchor assembly downwardly clear of the driven end of the casing;
said anchor assembly having a plurality of outwardly expandable flukes; and
said flukes having toe plates which have upwardly inclined surfaces so as to react with soil when the anchor assembly is driven downwardly, thereby outwardly expanding said flukes.

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