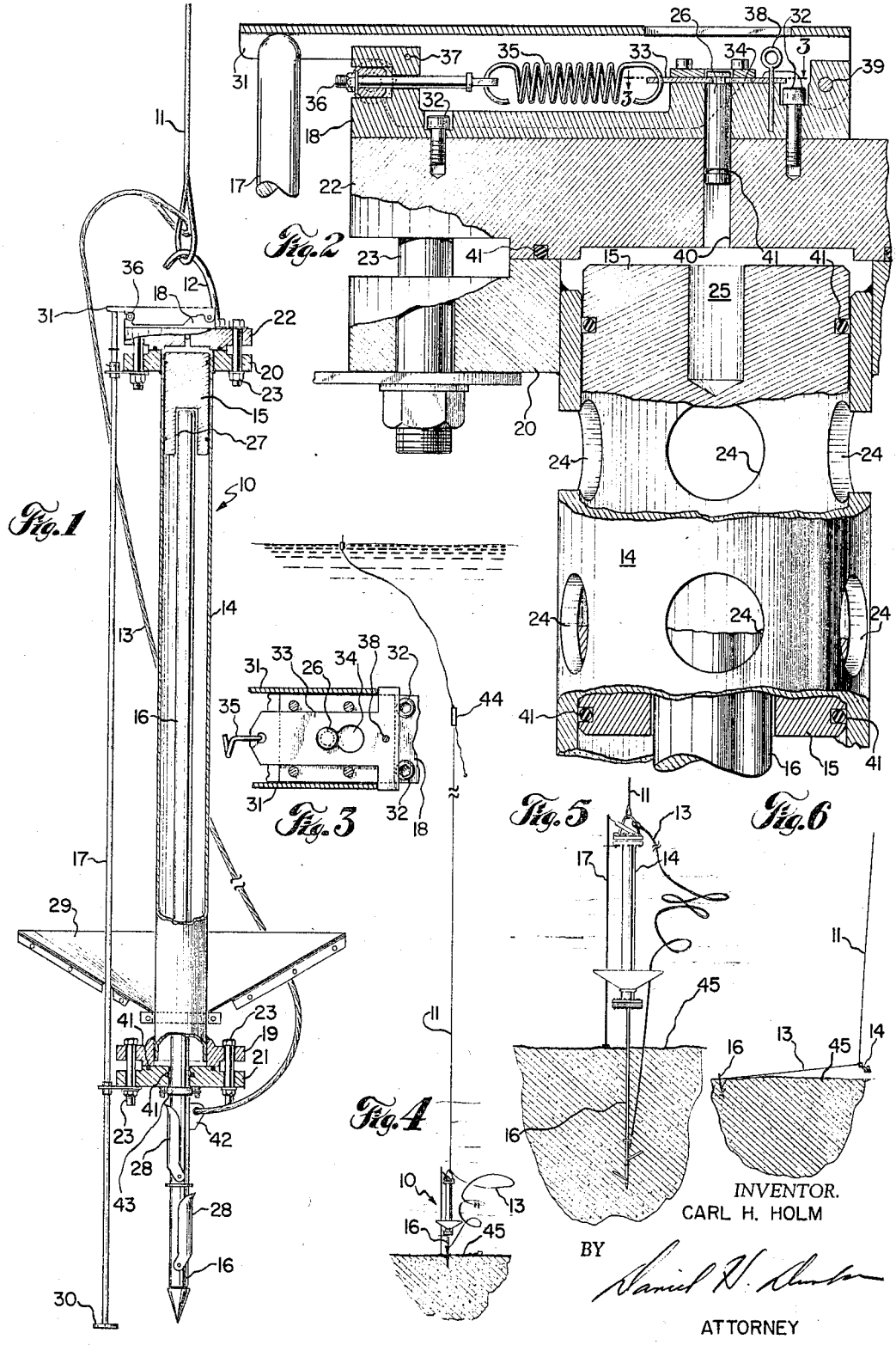
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MARINE ANCHOR

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MARINE ANCHOR

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This invention relates generally to marine anchors, and particularly concerns an anchor assembly having provisions for forcible anchor fluke embedment. From an applications standpoint, the invention is considered especially useful in instances where taut line mooring is required.

The instant marine anchor invention is essentially comprised of a cylinder and a piston-driven anchor shaft having attached outwardly rotatable anchor flukes. The piston-driven anchor shaft is powered for embedment purposes essentially by environmental water. The interior of the cylinder normally contains air at ambient atmospheric pressure and at the time of anchor actuation fluid openings in the cylinder upper exterior are uncovered permitting environmental water to flow into the cylinder upper interior and act upon the piston; forces developed from the pressure difference between environmental hydrostatic pressure and the atmospheric pressure of the contained air compress the air contained in the cylinder lower interior below the piston and rapidly deploy portions of the anchor shaft and the extending anchor flukes downwardly into the anchoring medium. Such embedment is accomplished by the invention without requiring the use of an explosive propellant charge.

A primary object of this invention is to provide a marine anchor assembly with means to advantageously utilize environmental water and the hydrostatic pressure condition associated therewith for accomplishing anchor shaft and anchor fluke embedment.

Another object of this invention is to provide a marine anchor assembly utilizing environmental water and the hydrostatic pressure condition associated therewith to accomplish anchor shaft and anchor fluke embedment with a construction and means to develop comparatively high anchor shaft embedment accelerations from such hydrostatic pressure condition.

A still further object of this invention is to provide a marine anchor assembly with a construction that does not incorporate or require the use of an explosive propellant charge to develop the forces necessary for accomplishing adequate anchor fluke embedment.

Other objects and advantages of this invention will become apparent during consideration of the following specification and drawings.

In the drawings:

FIG. 1 is a combined elevational and sectional view of a preferred embodiment of the marine anchor assembly of this invention;

FIGS. 2 and 3 are partial sectional and plan views showing additional details of the marine anchor assembly of FIG. 1; and

FIGS. 4 through 6 are elevational views showing the marine anchor assembly of FIGS. 1 and 2 at various stages in a typical deployment.

A preferred embodiment of the marine anchor invention of this application is designated **10** in the drawings. In the FIG. 1 view it is illustrated as being suspended from the lower extreme of anchoring cable **11** by means of attachment bail **12**. The object to be anchored is normally secured to assembly **10** at the other extreme of anchor line **11**. For taut line mooring applications wherein it is desired that a damping weight be utilized, a cable **13** may be provided to connect the principal mass of assembly **10** to the embedded portions in spaced-apart relation and after separation for that purpose.

Anchor assembly **10** is essentially comprised of hollow cylinder **14**, interiorly-contained piston element **15**, anchor shaft **16**, and an operator **17**-initiator **18** combination for operatively initiating actuation of assembly **10**. Cylinder **14** is provided with end flanges **19** and **20** that carry lower and upper end caps **21** and **22**, respectively, through conventional fasteners **23**. Piston **15** is slidably contained within cylinder **14** and is of sufficient length to interiorly cover the fluid inlet ports **24** provided in the upper exterior region of cylinder **14**. Recess **25** is provided in the upper end surface of piston **15** to receive the sealing plug **26** when assembly **10** is actuated to accomplish anchor shaft embedment; the recess **27** provided in the lower end surface of piston **15** receives the upper end of shaft **16** in driving relation. The lower end of shaft **16** projects through a cooperating opening in end cap **21** and carries the retracted outwardly rotatable flukes designated **28**. A point configuration is preferably provided at the lower extreme of shaft **16**.

Assembly **10** is also preferably provided with a drag cone **29** in attached relation to the exterior of cylinder **14**. Cone **29** functions to develop added resistance to reaction movement of cylinder **14** and aids in accomplishing embedment of anchor shaft **16** and attached flukes **28**. In some applications (extreme anchoring depths) and assembly configurations (high inherent drag) use of a drag cone such as **29** may not be necessary.

Operator member **17** is essentially in the form of a rod and is provided with a foot portion **30**; further, operator **17** is slidably supported within the cooperating brackets that project laterally from end cap **21** and end flange **20**. The upper end of operator **17** cooperates with the rotatable lever portion **31** of initiator **18**.

As shown in FIG. 2 of the drawings, initiator **18** is secured to end cap **22** by conventional fastener devices **32**. The initiator includes a retainer slide **33** preferably having a keyhole slot **34**; the narrow portion of slot **34** is normally engaged with the illustrated peripheral recess provided in the upper portion of sealing plug **26** and retains sealing plug **26** in its illustrated FIG. 2 position until anchor **10** is actuated by sufficient upward movement of operator rod **17**.

Also, as shown in the drawings, a tensioned spring **35** is provided in initiator **18** to preload slide **33** and also the over-center detent mechanism designated **36**. A shear pin **37** may be provided to supplment detent device **36** and thereby minimizes accidental operation of lever **31** if desired; also, a pin **38** may be utilized to facilitate the assembly of anchor **10** during manufacture by retaining slide **33** in its restraining position but it must be removed prior to anchor deployment. Projecting ears may be included on slide **33** (FIG. 3) for cooperation with stops provided in the illustrated side flanges of lever arm **31** (FIG. 1). This arrangement serves to retain slide **33** and sealing plug **26** in their FIG. 2 restrained position so long as lever **31** is not moved upwardly. When lever arm **31** is rotated by rod **17** about pin **39**, the stops of the sides of lever **31** are disengaged from the side-projecting ears of slide **33** and spring **35** then moves the large portion of keyhole slot **34** into surrounding relation to sealing plug **26**. Plug **26** then is freed to move downwardly within the cooperating continuous cylindrical passageway **40** in end cap **22** and initiator **18**. Hydrostatic forces acting upon the upper end of sealing plug **26** will, when anchor assembly **10** is actuated and providing the associated hydrostatic pressure is greater than the pressure of the interiorly contained air, force plug **26** into recess **25** to accomplish initial flooding of the upper interior portion of hollow cylinder **14**.

Several other construction features of anchor assembly **10** are of interest. Conventional O-ring seals **41** are provided at obvious locations throughout assembly **10** to seal the interior of cylinder **14** from exterior environmental

pressure conditions. At the time of assembly the normal exterior environmental pressure, and thus the condition within cylinder **14**, is ambient atmospheric pressure. Lug **42** is attached to shaft **16** to assist in securing portion **13** of anchor line **11** to the lower extreme of the assembly. A shear pin (not shown) may be provided in assembly **10** to retain shaft **16** in its FIG. 1 position during normal handling; such shear pin, however, should not interfere with the actuation of assembly **10**. The top of piston **15** is preferably spaced apart from the under-surface of end cap **22** (FIG. 2). At the time of anchor manufacture a collar **43** is connected to shaft **16** to assure the necessary degree of spacing.

As suggested above, anchor assembly **10** is fabricated using conventional manufacturing techniques and when assembled includes air at ambient atmospheric pressures within cylinder **14**. As assembly **10** is lowered to considerable depths, the environmental medium (water) establishes substantial pressure differentials between the cylinder exterior and interior. The pressure differential which exists at the anchoring depth is employed to obtain the advantages of this invention.

A prototype anchor assembly **10** having a hollow cylinder **14** approximately 6 feet long was provided with a cooperating piston **15** of approximately 5 inches diameter. The piston length was approximately 10 inches to cover an arrangement of two circumferential rows of five fluid inlets each in the cylinder upper exterior region; each inlet opening had a diameter of approximately 1¾ inches. The drag cone **29** attached to cylinder **14** had an overall diameter of approximately 3 feet. A hollow anchor shaft **16** that was 1⅝ inches in diameter extended from piston **15** and through the lower end of the cylinder by a distance of approximately 20 inches; the projecting anchor shaft was provided with two generally opposed rotatable anchor flukes **28** each having an overall length of approximately 7 inches extended. The prototype unit was assembled under normal conditions so that the unoccupied interior of cylinder **14** contained air at standard atmospheric pressure.

Assembly **10** was lowered at sea approximately 1,000 feet to bottom and was actuated in the manner shown by FIGS. 4 through 6. On contact with anchoring medium **45**, reaction forces introduced into rod **17** at foot portion **30** cause upward movement of initiator lever **31** relative to the anchor assembly. A small degree of clockwise (FIG. 2) rotation of lever arm **31** about axis **39** released slide **33** for movement by tensioned spring **35**. Movement of slide **33** resulted in disengagement of sealing plug **26** from restraint within keyhole slot **34** thus permitting the environmental hydrostatic pressures (approximately 450 p.s.i.) to force sealing plug **26** into recess **25** and thereby open passageway **40**. Seal water ported through passageway **40** into the space intermediate piston **15** and end cap **22** caused downward displacement of piston **15** and initial compression of the air at atmospheric pressure within the unoccupied lower interior portion of cylinder **14**. Such relative downward displacement of piston **15** further caused the complete opening of fluid inlets **24** thereby admitting fluid at environmental hydrostatic pressures into the cylinder interior intermediate end cap **22** and upper surface of downwardly displaced piston **15** at a high flow rate thereby causing piston **15** to further compress the air in cylinder **14** to an equilibrium pressure. The rapid compression of contained atmospheric air is accompanied by comparatively high relatively downward acceleration of shaft **16** in opposition to reaction inertia of cylinder **14** and the components carried thereby and also in opposition to the resistance resulting from drag cone **29** if employed in the invention construction. Such rapid downward acceleration in opposition to the concurrent reaction forces causes a substantial penetration of shaft **16** and attached anchor flukes **28** into the anchoring medium **45**. See FIG. 5. On completion of anchor shaft and fluke embedment, underwater turbulence forces acting on anchored sonobuoy **44** (the object to be anchored) and through anchoring cable **11** may be utilized to disengage cylinder **14** from shaft **16**. The mass of cylinder **14** provides a damping effect for taut line mooring applications yet cable **11** remains connected to shaft **16** through cable section **13**. Withdrawal forces acting upon anchoring cable section **13** cause limited withdrawal of anchor shaft **16** and simultaneous rotation of anchor flukes **28** to an extended position. FIG. 6 shows assembly **10** in its typical finally deployed condition.

It is to be understood that the forms of the invention herewith shown and described are to be taken as preferred embodiments of the same, but that various changes in the proportioning, size, and detail of parts may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims.

I claim:

1. A marine anchor assembly for actuation by environmental fluid having an associated hydrostatic pressure that substantially exceeds atmospheric pressure, and comprising:

(a) Hollow cylinder means having closed upper and lower ends and having an interior that contains gas at a pressure essentially corresponding to atmospheric pressure,

(b) Anchor shaft means partially within said cylinder means interior and slidably projecting through said cylinder means closed lower end with attached anchor flukes positioned below said cylinder means,

(c) Piston means cooperatively positioned in said cylinder means in driving relation to said anchor shaft means and separating said cylinder means interior into upper and lower portions each of variable volume, and

(d) Inlet port means located in the upper region of said cylinder means and arranged to conduct actuating environmental fluid from regions exterior to the anchor assembly into said cylinder means upper interior portion when opened,

said inlet port means being closed from communication with said cylinder means upper interior portion by said piston means prior to actuation of the anchor assembly and being opened as a result of initial downward movement of said piston means relative to said cylinder means to thereby conduct sufficient actuating environmental fluid into said cylinder means upper interior portion to continuously compress the gas contained in said cylinder means lower interior portion to an equilibrium pressure corresponding to the hydrostatic pressure of the environmental fluid, to substantially accelerate said piston means and said anchor shaft means downwardly relative to said cylinder means, and to consequently embed said anchor shaft means in an anchoring medium.

2. The invention by claim **1**, wherein said piston means is provided with longitudinal spaced-apart seal means, and wherein said inlet port means is comprised of peripherally positioned cylinder means openings, said piston means being positioned prior to actuation of the anchor assembly so that said inlet port means is located intermediate said longitudinally spaced-apart seal means to further close said inlet port means from communication with said cylinder means interior upper and lower portions.

3. The invention defined by claim **1**, wherein said cylinder means is additionally provided with separate means positioned in cooperation with said cylinder means interior upper portion for initiating actuation of the marine anchor assembly, said separate means conducting environmental fluid to said hollow cylinder means interior upper portion when actuated to initially compress the gas contained in said cylinder means lower interior portion and consequently move said piston means downwardly relative to said cylinder means a sufficient distance to change said inlet port means from a closed condition to

an open condition to additionally conduct environmental fluid to said cylinder means interior upper portion.

4. The invention defined by claim 3, wherein said separate means includes a passageway means extending from the anchor assembly exterior to said cylinder means interior upper portion, sealing plug means positioned in said passageway in longitudinal sliding relation, recess means in said cylinder means interior upper portion large enough to more than completely receive said sealing plug means, and restraining means preventing longitudinal sliding movement of said sealing plug means relative to said passageway and said recess means when engaged with said sealing plug means, said initiator means disengaging said restraining means from said sliding plug means when actuated to permit environmental fluid to cause said sealing

plug means to be longitudinally moved into said recess means and thereby permit environmental fluid to be conducted into said cylinder means interior upper portion through said passageway means to initially move said piston means downwardly relative to said cylinder means and open said inlet port means.

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