July 14, 1970 B. L. BOWER 3,520,268

BALLISTICS EMBEDMENT ANCHORS

Filed June 22, 1967 3 Sheets-Sheet 1

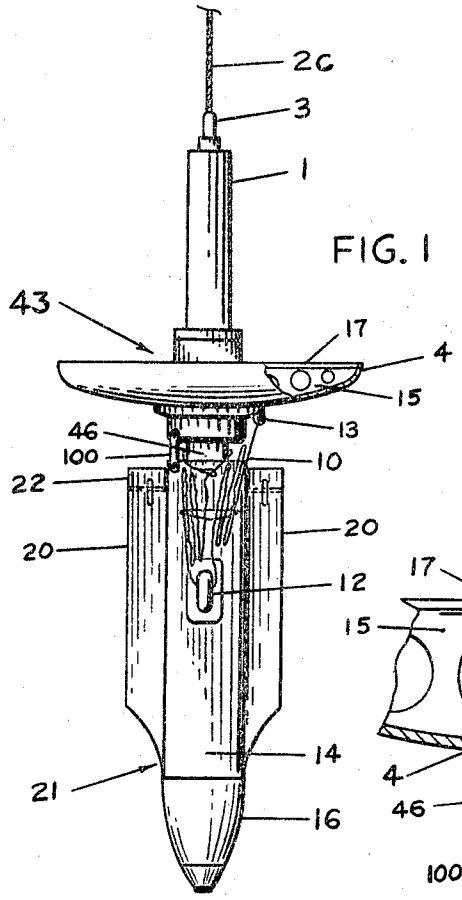


FIG. 1

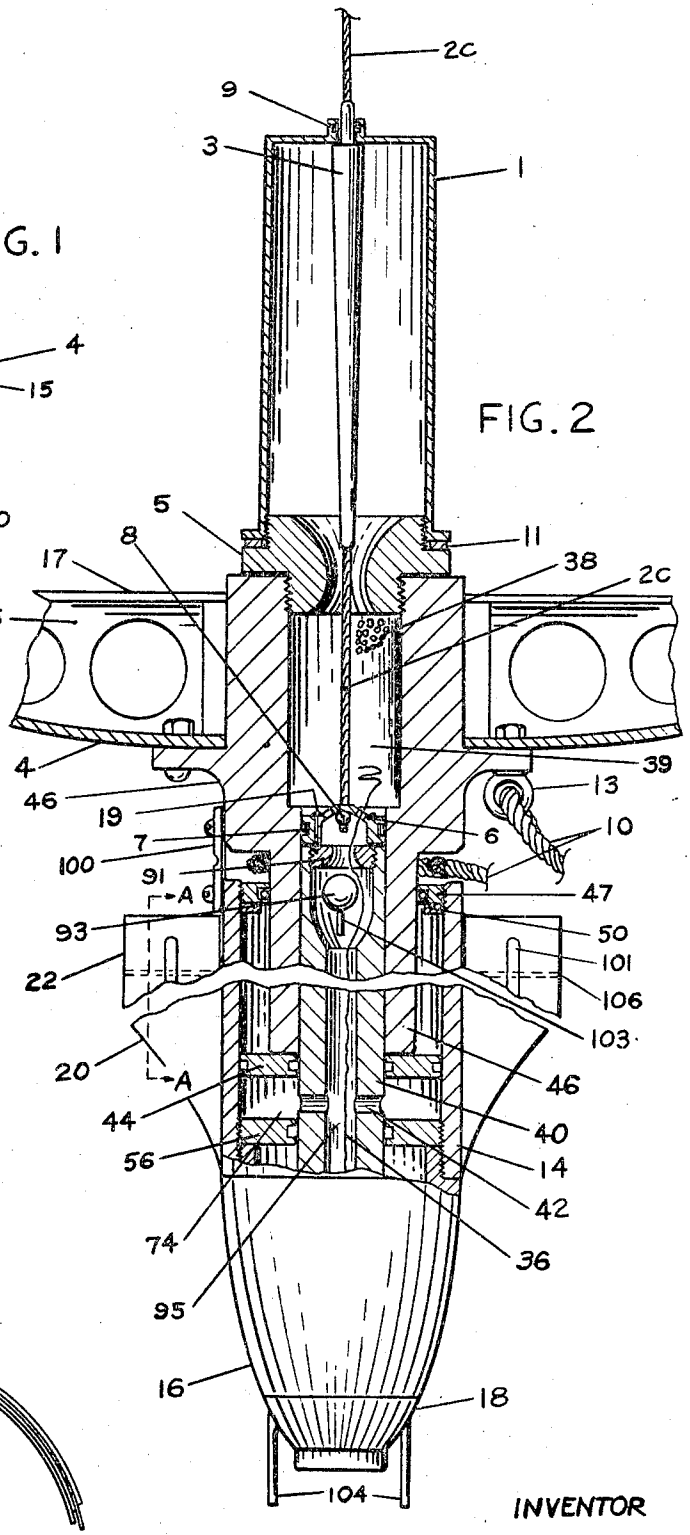


FIG. 2

FIG. 2b
SECT. A-A

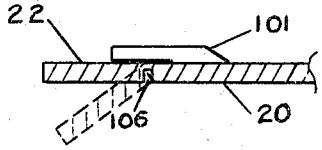
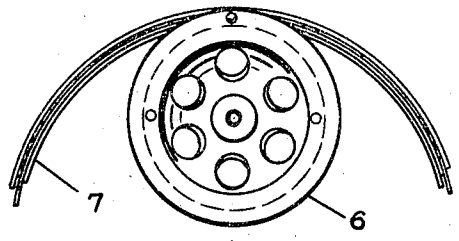


FIG. 2a

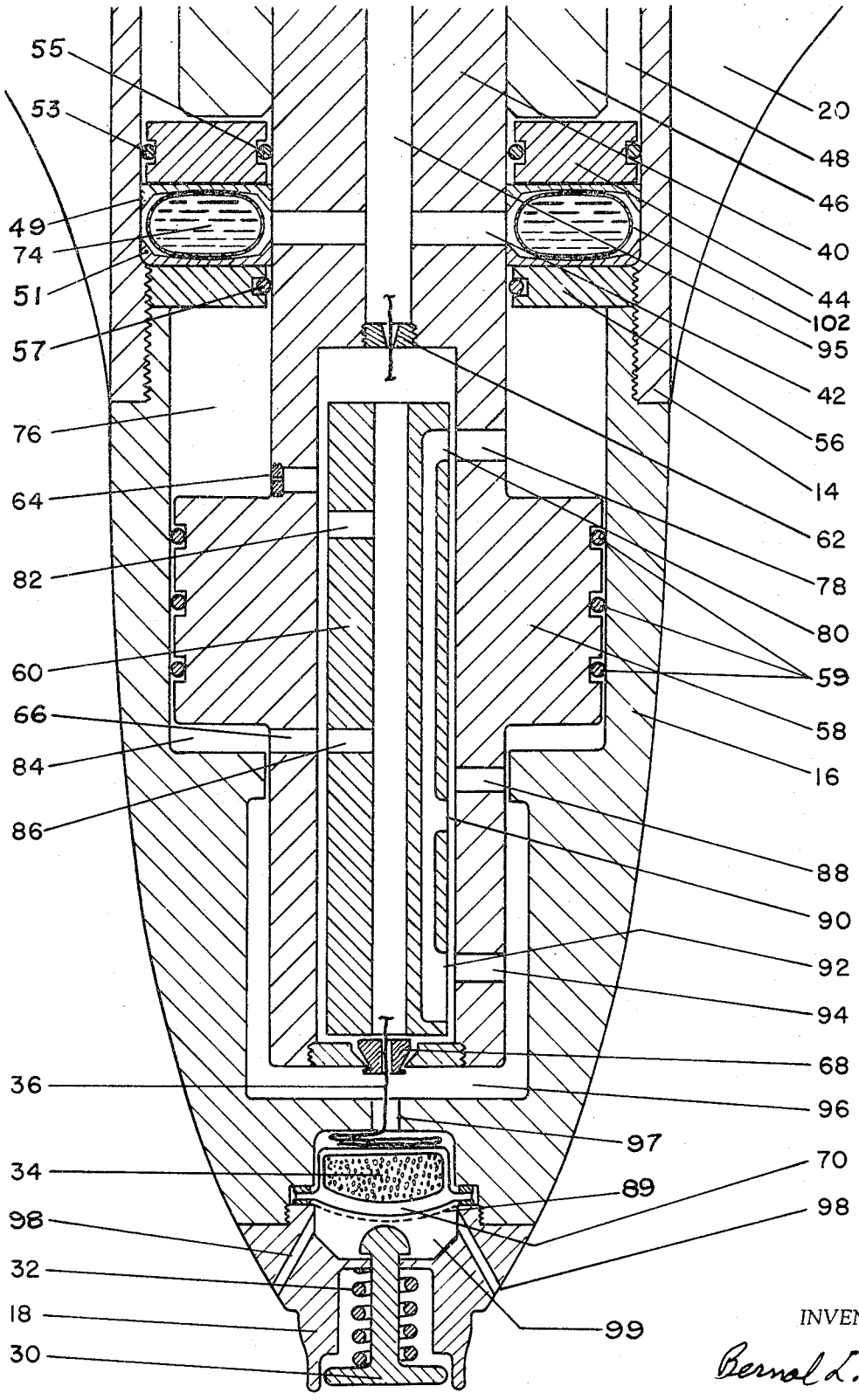


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BALLISTICS EMBEDMENT ANCHORS

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FIG. 3

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FIG. 4

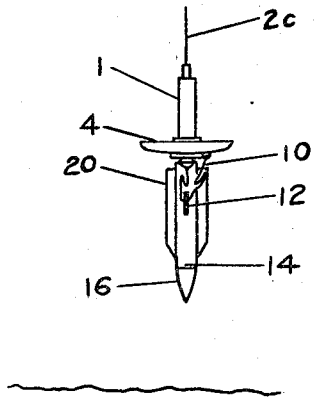


FIG. 5

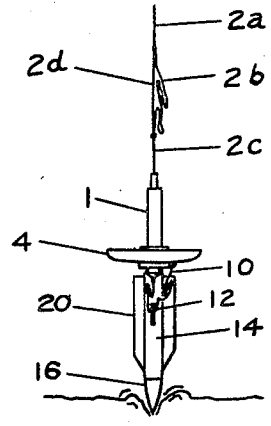


FIG. 6

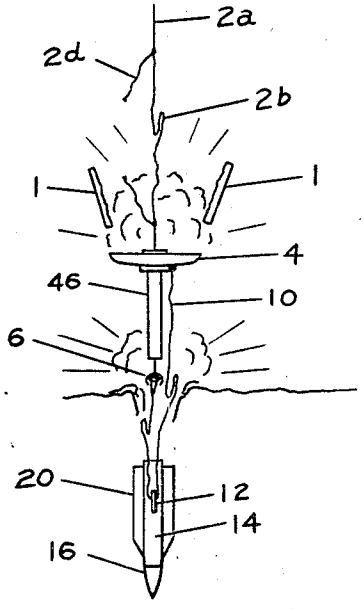


FIG. 7

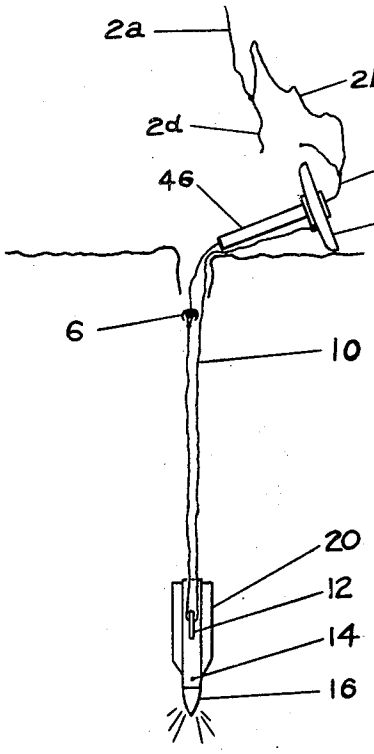


FIG. 8

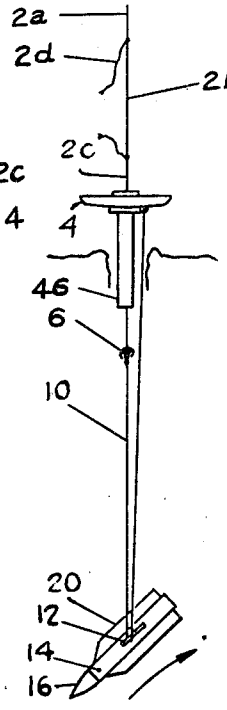
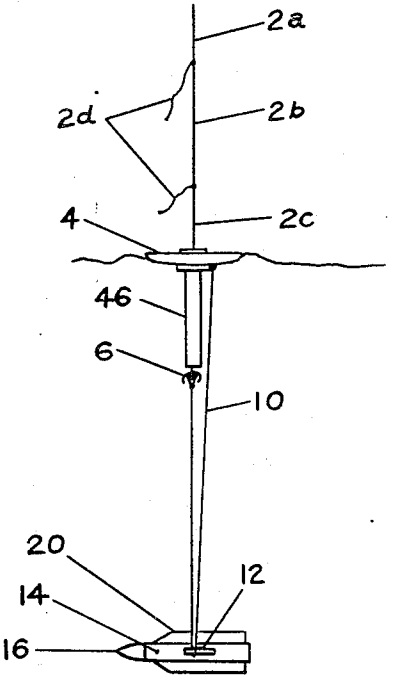


FIG. 9



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United States Patent Office 3,520,268 Patented July 14, 1970

3,520,268

BALLISTICS EMBEDMENT ANCHORS

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Filed June 22, 1967, Ser. No. 654,301
Int. Cl. B63b 21/28
U.S. Cl. 114—206 32 Claims

ABSTRACT OF THE DISCLOSURE

An embedment anchor utilizing a combination of ballistics, inertial, and jetting driving means for providing deep penetration into a body of material from which location the anchor, although being a relatively light weight mechanism, is capable of resisting large vertical or horizontal, intermittent or continuous strains from any direction over a long duty life. A large portion of the propellant gases under internal ballistics pressures is retained in the anchor following its separation from the reactor, and the thermodynamic energy remaining to these gases is utilized to provide additional penetration into the body of material. Pressure staging is employed to adapt gas working pressure to the ability of the anchor structure to withstand stresses resulting from these internal ballistics pressures, making possible a considerable saving in weight. The anchor includes means for maintaining propulsion chamber pressure constant from short start to anchor and reactor separation thus greatly increasing anchor overall efficiency over current design. Impulse of the shot is reacted by maintaining a large pressure differential across a portion of the reactor during the ballistics phase of penetration. The anchor reactor is utilized also for providing a protecting shroud and fair-lead for the mooring cable, and footing in the body of material against which the cable bears preventing large unit loads being placed directly on the material by the mooring cable. A novel working seal for stopping high temperature gas at ballistic pressures, and also having other ordnance application, is disclosed.

The purpose of this invention is to provide a deep penetrating embedment anchor for use in marine applications where taut-line mooring systems are required. Whereas, in the present state-of-the-art, embedment anchors of the ballistics type have been designed and tested, results have been disappointing for several reasons of which the following are the more cognent.

(1) It has been virtually impossible to achieve the required penetrating depths with anchors of current design.

(2) The internal ballistics characteristics of the propellant grain is such that its peak gas pressures, acting only for a few microseconds, dictate anchor design whereas average operating pressures are about one-tenth to one-quarter of this magnitude. Thus the anchor is heavier and bulkier than efficient design would indicate.

(3) The danger to personnel handling and operating anchors of this type make it necessary to provide intricate and costly safeing devices thus increasing manufacturing costs and rendering the product economically unfeasible.

(4) Too great a portion of the energy available from the propellant grain is wasted at separation of the anchor and reactor members if design is held within dimensional feasibility.

(5) The reaction member of current designs is massive and large in order to produce the mass and drag reactions necessary to offer a stable firing platform for the imbeding portion of the anchor.

(6) After the anchor is placed, permanency of the mooring requires that the cable be prevented from chaffing on the bottom material, and that as the mooring swings with the tides or winds the cable must not work in the

bottom material so as to dig out the imbedded anchor. Current designs are singularly deficient in this regard.

The anchor device disclosed herein combines a plurality of methods for penetrating the ocean bottom together with novel concept of ballistics mechanism as well as novel safeing features in such a way that the above listed undesirable characteristics have been circumvented.

In the drawing FIG. 1 shows the anchor member **21** and some of its components: fins **20**, casing **14**, nose section **16**, shackle eye **12**, anchor cable **10** etc., mated with the reactor member **43** with its components: mooring cable **2** fracture barrel **1**, obturator nozzle plug **3**, reactor head **4** shackle eye **13**, etc. In FIG. 1 part of the head shell is cut away showing the reactor head assembly construction which includes radial webs **15** and their caps **17**.

FIG. 2 is a drawing in section showing the anchor and reactor in greater detail than FIG. 1. FIG. 2 shows ignitor body **18**, anchor head structure **56**, radial ports **42**, ring piston **44**, reciprocating inertial reactor (RIR) **40**, check valve ball **93**, check valve ball stop **103**, check valve orifice **91**, reactor barrel **46**, ring piston stop **50**, propellant grain **38**, breech obturator nozzle **5**, RIR sabot **6**, and sabot expander ring **7**, obturator nozzle variable throat plug **3**, fracture barrel **1**, and associated seals **9** and **11**, and other of the embedment anchor parts.

FIG. 2*a* is a detail view in plan showing the RIR sabot **6**, and sabot expander ring **7**, showing the gas passage holes through the sabot web structure.

FIG. 2*b* is a sectional view of the slotted fins taken along section line A—A in FIG. 2.

FIG. 3 shows the forward portion of the anchor in section wherein the ignitor body **18**, and its component parts are shown in detail. In FIG. 3 the forward portion of the RIR **40**, together with its free sliding valve **6**, choking nozzle **62**, restrictor plug **64**, swage plug **68**, and gas ports **80**, **90**, **92**, **82**, **86**, **78**, **88**, **94** are shown. Also shown in FIG. 3 are the ring piston **44** and anchor head structure **56** and their related seals **49** and **51** respectively.

FIGS. 4 through 9 illustrate the anchor embedment operation. FIG. 4 shows the embedment anchor assembly being lowered to the ocean bottom on mooring cable **2**. FIG. 5 shows the anchor assembly striking the ocean bottom material. FIG. 6 shows the anchor member separated from the reactor member immediately subsequent to the ballistics phase and just prior to initiation of the inertial and jetting phase of bottom penetration. FIG. 7 shows the anchor during the inertial and jetting phase of penetration. FIG. 8 shows the anchor being keyed into the horizontal position. FIG. 9 shows the anchor member and the reactor member in their final keyed positions.

Prior to operation the fuse cord **36** is threaded or drawn through the various anchor components by a pilot cord (not shown), and coiled in the primary propulsion chamber **39** so as to be contiguous with the propellant grain **38** when charged into the chamber. Fuse ignitor **70**, is then assembled in place ahead of the other coiled end of fuse cord **36**, with gaskets in place. Ignitor body **18**, is assembled in anchor body **16**, by screwing into place against the gasket seals. The propellant grain **39** is then charged into the primary propulsion chamber through the breech obturator nozzle opening, and fracture barrel **1**, is replaced. In the event that choking nozzle **62** must have a smaller throat diameter than would conveniently pass the fuse cord **36** choking nozzle **62** may be packed with the fuse powder material and the fuse cord **36** made up of two lengths, one end of each length being fastened to one side of the packing. With such a fuse assembly installation of the fuse would best be accomplished during anchor final assembly at the factory. Of course, the fuse cord **36** could be routed via some other path to the propellant charged if desired. The reactor head **4** is assembled by bolting it to the reactor barrel **46**, if the anchor

has not been stored with the reactor head already assembled. The cable assembly including the slack portion of the mooring line 2*b* and halter 2*d* are shackled to the stub line 2*c* as shown in FIG. 5.

In operation the readied anchor is attached to its mooring cable 2*a* and lowered over the side of the vessel placing the mooring.

When the anchor strikes the ocean bottom, contact with the bottom material actuates the trigger plunger **30** located in the ignitor body **18** forcing it in against the action of spring **32**, and driving the hammer end of the plunger into the glass container **70**, breaking it and exposing its metallic sodium coated sand grains **34** to ambient sea water which enters through the jet exhaust ports **98** in the ignitor body. The heat and pressure generated by the exothermic chemical reaction of the metallic sodium and water breaks the seal afforded by the aft face of the glass container and ignites the fuse cord **36**. The fuse cord burns throughout its length and subsequently ignites the propellant grain **38**. At the instant of grain ignition the gases at high pressure produced thereby flow through the breech obturator nozzle **5** and break the frangible barrel **1**. The broken pieces of barrel **1** are blown away from the reactor member leaving the combustion chamber open and vented to the area immediately aft of the reactor head **4**. Burning of the propellant grain produces gas at high pressure to provide force acting on the anchor member and the reactor member. The reactor member offers a stable firing platform for the shot and the anchor member is driven into the ocean bottom material.

The grain configuration is chosen such that it has essentially neutral burning characteristics. That is, the gap production rate is constant under burning conditions at constant chamber pressure. The gas production rate at the desired chamber pressure is a function of the quantity of propellant charge used for the shot, and is chosen such that at the instant of separation of the anchor member from the reactor member the gas produced by the burning grain is just sufficient to maintain the desired chamber pressure under the conditions of increasing chamber volume and gas flow through both the check valve orifice **91**, and the throat of the breech obturator nozzle **5**. The throat area of the breech obturator nozzle is made variable by the relative position of the breech obturator nozzle throat plug **3** and is a minimum at the instant of separation of the anchor member from the reactor member. The rate of increase of propulsion chamber volume is a function of the dynamics of the anchor, and is directly proportional to the relative velocity of separation of the anchor member from the reactor member. As the velocity of separation increases to a maximum at the point of separation the rate of increase in chamber volume correspondingly increases. Since the rate of increase in chamber volume is always less than the rate of increase at separation, and gas flow through the check valve orifice **91** is substantially constant, the gas production rate would be too great to maintain the chamber pressure at its design constant value prior to separation if it were not for the variable throat area feature of the obturator nozzle. Breech obturator nozzle throat plug **3** is made tapered or of such contour that at each instant during the separation of the anchor and reactor members its section at the position of the obturator nozzle throat as it is drawn through the nozzle, is of correct diameter to provide just the required throat area and therefore the required gas flow, to maintain the chamber pressure constant at the desired value.

During the initial peak pressures the gas is substantially confined to the strongest portion of the primary propulsion chamber, that is, the reactor breech portion **39** where its pressure acts directly against the piston area afforded by the aft face of the RIR shaft. The initial extreme peak pressure is contained adequately by the mechanical integrity of the reactor breech. The reactor breech is the only part of the anchor assembly for which it is necessary to design for the initial high peak internal ballistics pressures, and therefore considerable saving in anchor gross weight is possible with this design feature, and the very heavy parts of the anchor assembly are confined to the reactor member where the weight is useful in taking the recoil of the system in the ballistics phase of the embedment operation.

An additional benefit provided by the feature of the open propulsion chamber is that of the action of the high pressure vented gases on the rearward face of the reactor head to produce a pressure reaction force which opposes the thrust of the propulsion gases against the reactor member. The efficiency of the ballistics phase of anchor penetration is thereby increased. Effective reaction during the ballistics phase of penetration is obtained without the requirement for a heavy, excessively large reactor head.

The internal ballistics pressures act initially on the aft face of the RIR shaft and its sabot **6** driving the RIR shaft forward against the forward face of the chamber **96** in the nose of the anchor member, and swagiing closed the fuse access port in the swage plug **68**. The forward acceleration of the RIR **40** with anchor member **21** together (the anchor member being driven by it) forces the RIR valve **60** to its aft seat in its bore thus aligning its aft intake port **82** with the aft intake port **65** in the RIR piston **58**.

Simultaneously, propellant gases under high pressure flow through the check valve orifice **91** and around the check valve ball **93** through the axial passage **95** in the RIR to the choking nozzle **62**. The pressure drop through the choking nozzle **62** is maintined above critical so that the gases flow into the RIR valve at a predetermined flow rate depending upon the size of the throat in the choking nozzle and the thermodynamic conditions ahead of this nozzle. The choking nozzle **62** impedes the flow of the high pressure gases so that they exhaust through the radial ports **42** in the RIR shaft wall and into the secondary propulsion chamber **74** formed by the outside diameter of the RIR shaft and the inside diameter of the anchor casing **14**. The gases in this chamber are obturated by the ring-piston **44** and provide force acting on the anchor head structure **56** to drive the anchor member forward into the ocean bottom.

It will be noted that a novel method of pressure staging is employed to adapt gas working pressures to the ability of the structure to withstand stresses resulting from such pressures. The high gas pressures existing in the primary propulsion chamber **39** immediately subsequent to the initial maximum peak are confined to the relatively small bore of the reactor barrel **46** and to the heavy breech. Gas pressure beyond check valve orifice **91** is considerably reduced. Thus these gases when vented into the secondary propulsion chamber **74** through ports **42** are at a working pressure which is consistant with the larger bore and design of the lighter anchor casing **14**. The maximum peak pressure which persists for only a few microseconds is adequately handled by the heavy reactor breech.

The ballistics phase of anchor embedment is effected by a force composed of two components. One component consists of the force equivalent of primary propulsion chamber high pressure gases acting directly over the area of the RIR shaft sabot **6**. The other component consists of the force equivalent of secondary propulsion chamber propellant gases acting at reduced pressure over the larger area of the face of ring piston **44**.

The impulse created by the burning propellant grain is both mass and pressure reacted. The mass of the heavy reactor acts to minimize reactor recoil as does the heavy breech and barrel of a rifle when it is fired. In addition a novel means for increasing the resistance to recoil, or to the rearward movement of the reactor, is employed in this anchor device. It consists of maintaining a high pressure region at the rearward face of the reactor head **4** throughout the very short period during which the impulse acts to discharge the anchor member from the re-

actor member. This pressure method of reacting the impulse created by the burning propellant is described in greater detail below.

The gases produced by the burning propellant grain are at high temperature as well as at high pressure. The pressure of the gases will be reduced as the gases flow through the choking nozzles and ports of the anchor mechanism. However, the high temperature of the gases will not be reduced much thermodynamically through these nozzles because the flow will be essentially irreversible adiabatic in nature. Thus, the working seals will be subject to gases at high temperature and at high pressure. The material comprising the O-ring seals must, therefore, be protected from these damaging temperatures. A unique concept for the design of the seals is employed in this invention. A shoe **49, 51** made of sintered metal or other porous material capable of withstanding high temperatures, impregnated with a high temperature colloidal graphite lubricant dispersed in a non-combustible vehicle having moderate viscosity at high temperatures acts as a primary seal and heat barrier for the O-ring seal. The channel flanges of the shoe **49, 51** are made a close fit to the surface of the secondary propulsion chamber walls, and may be tapered to a relatively thin edge. The shoe flanges are made a slight interference fit to the walls of the secondary propulsion chamber and are deflected to permit the assembly of the shoe in the chamber. The O-ring **53, 55, 57** is made of some suitable high temperature relatively hard plastic material such as Teflon or it may be a metal ring if required. All free volume ahead of the O-ring is packed with the graphite lubricant. Upon application of the high temperature, high pressure gases to the seal, the graphite lubricant becomes fluid and lubricates the sliding surfaces, and acts as a heat barrier between the hot gasses and the O-ring. The O-ring acts effectively as a seal against a liquid rather than a gas, and is thus protected from the direct application of the hot gases. If desired the body of the sabot **6** may be made a sintered metal seal and brazed or welded to the solid metal web. Shoe **49, 51** may be brazed or welded to ring piston **44** and anchor head structure **56**, respectively.

It is likely that this new type of working seal will find wide application in primary and secondary mechanisms of many kinds of ordnance weapons and ordnance machinery as, for example, in both heavy and light rifles and other field pieces where gas leakage under ballistics pressures and temperatures results in loss of thermodynamic efficiency and excessive erosion and wear of metal surfaces. This seal could be used in the bore of a rifle to seal off gas flow past the projectile and to positively lubricate the rifle bore with every shot. In this application a portion or all of the base of the projectile would be composed of a lubricant impregnated sintered metal material such as copper. This metal structure being porous and very ductile would compress easily to conform to the cross sectional configuration of the rifle bore including the rifling lands. The diameter of the sintered metal seal could be made slightly larger than the diameter of the bore of the rifle, and being porous and ductile would compress easily on entry into the rifle bore. Being slightly compressed the seal would extrude a portion of its impregnated lubricant onto the surface of the bore. The mechanism of the action of the gases at ballistics temperatures and pressures on the lubricant impregnated sintered metal base of the projectile would be to heat, liquify and extrude the lubricant into the clearance between the sliding surfaces of the projectile and the rifle bore. The projectile would thus literally slide on a thin film of the liquified lubricant. The effect of this mechanism would be to provide an effective barrier to the flow of gases past the projectile throughout its travel down the bore of the rifle to the muzzle. In addition, every section of the bore throughout its length would be lubricated with each shot, greatly increasing the useful life, muzzle velocity and

accuracy of the rifle. The seal may also find wide application in the secondary mechanisms of ordnance machinery such as the mechanisms of automatic weapons in which a portion of the propellant gases is used to drive the reloading mechanism.

Because a considerable portion of the energy contained in the combustion gases is by virtue of their high temperature and because of the ready dissipation of this energy in the form of heat transfer into and through the anchor structure it is desirable to convert the heat energy in the accumulated gases to energy of another form as soon as possible. That is, it is desirable to reduce the temperature of the combustion gases without reducing their pressure thereby. To do this a quantity of distilled water in a suitable combustible container **102** is placed in the free volume of the secondary propulsion chamber **74** as shown in FIG. 3. The hot gases from the burning propellant grain rupture and ignite this combustible container on contact with it. The water flashes off into superheated steam reducing the temperature of the gases. The result is a mixture of water vapor and hot gases at reduced temperature. The reduced pressure of the gases is compensated by the partial pressure of the water vapor so that the mixture of water vapor and combustion gases attains to approximately the same total pressure as the gases before the mixing, but at considerably lower temperature. The reduced temperature of the gas mixture posses less a problem in the design of the working seals.

At separation of the anchor member **21** from the reactor member **43** the ballistics phase of the anchor embedment is completed. The anchor member moves forward under its own momentum, further penetrating the ocean bottom during the transitional phase between ballistics embedment and inertial embedment, its stored kinetic energy converting to work in moving the anchor against the resistance of the ocean bottom material.

After separation the external pressure acting on the aft face of the RIR shaft **40** drops to ambient hydrostatic. The pressure difference then existing across the check valve ball **93** forces this valve against its seat and closes off the port against passage of the high pressure internal gases to ambient. At the point of separation, the ring-piston **44**, seats against its soft metal stop **50** closing off passage of the high pressure internal gases to ambient through this source. O-ring seal and retainer **47** prevent water from entering into the interior of the anchor casing **14** during the time the anchor assembly is being lowered to the ocean bottom. This O-ring is soft and is blown out by the compressed air in the free volume between the reactor barrel **46** and the anchor casing **14** during separation of the anchor member from the reactor member. Retainer **47** backs up the soft metal stop **50** and takes the load placed on stop **50** by the ring piston **44**.

The energy remaining at separation to the mixture of propellant gases and water vapor under internal ballistics pressures is subsequently utilized to drive the anchor member to its maximum embedment depth. Two separate means are employed to efficiently trade off this remaining energy for embedment depth. One of the means is inertial; the other is jetting.

Bottom penetration by the inertial means is effected by using a part of the energy contained in the retained high pressure gases and superheated steam to drive the RIR **40**. The RIR may be driven in such a way that either its forward movement or its reverse movement is made at a velocity much greater than the return stroke. The choice of rapid forward or rapid reverse movement would depend on the type and characteristic of ocean bottom materials at the mooring site. Hard bottom materials exhibiting great frictional and compressive resistance to penetration would perhaps dictate the use of a rapid forward stroke. The heavy RIR would acquire a maximum of kinetic energy in the forward direction at the instant it bottoms in its bore. Its stored kinetic energy would,

at impact, be transferred through anchor member structure in an impulse shock which would be more effective in breaking through harder bottom materials such as coral, of example. The greater frictional resistance of the coral would hold the anchor against retraction on the forward stroke of the RIR as it accelerated up to speed. For penetration of the ocean bottom "oozes" a fast reverse stroke might be more efficient, if frictional resistance of this material is slight. On acceleration of the RIR in the reverse direction the anchor body would respond by driving forward a distance very nearly corresponding to the travel of the RIR if the weights of the RIR and the remaining anchor member structure were about equal. The energy of the shock reaction at the termination of the reverse stroke would be better absorbed by frictional forces of the bottom medium and result in very little anchor displacement upward. The slow forward return stroke of the RIR would not cause anchor displacement, the frictional forces of the bottom material and weight of the anchor being sufficient to hold the anchor against the force (pressure X area) reaction. Internal damping of the RIR at termination of its reverse stroke may be utilized if found desirable. This might be accomplished by locating the exhaust ports **78, 88** so that they close before the RIR terminates its stroke in either direction. It is difficult to predict precisely what velocity profile will give most efficient penetration in a given bottom material and tests would be required in the development of the anchor system to provide this information.

Bottom penetration by the jetting means is most efficient in sandy bottoms, or bottom materials which are susceptible to displacement by a high velocity gas jet. Bottom penetration by jetting results from ducting the exhaust gases from the RIR cylinders **76, 84** through orifices **98** in the nose of the anchor member. The high velocity gas jet penetrates the sandy medium ahead of the anchor. Subsequent expansion of the gases breaks up the compacted material ahead of the anchor and makes possible easy penetration of the loosened flocculent material. For operation in sandy or sedimentary bottoms small nozzles or pipes **104** which protrude beyond the forward extremity of the anchor nose could be used to inject the exhaust gases into the bottom material ahead of the anchor nose thus loosening and breaking up the compacted bottom material well ahead of the anchor member.

The jetting means of penetration is used simultaneously with the inertial means. With both penetrating means cooperating together, the anchor continues to penetrate the ocean bottom material utilizing most of the energy available in the mixture of propellant gases and superheated steam above the hydrostatic ambient pressure level.

If the operation depth or penetration requirements for the anchor are such that longer operation of the inertial and jetting phase of anchor penetration appears desirable, the addition of a slow burning propellant with a time delay fuse may be installed in the free volume of the secondary propulsion chamber, or the gases from such a gas generator located elsewhere on the anchor member may be ducted into the secondary propulsion chamber to prolong the inertial and jetting phase of anchor penetration.

At the instant of separation of the anchor member from the reactor member, the anchor member begins to decelerate as it moves forward into ocean bottom material, utilizing its stored kinetic energy for further immediate bottom penetration. Deceleration of the anchor member causes RIR valve **60** to slide forward against its forward seat. It first contacts the soft metal swage plug **68** swaging closed the aft end of its bore. This swaging action is precautionary only and ensures a positive seal against the ineffiecient exhaustion of gases through a possible leak in the plug left following the first swaging

closure of its forward end at propellant grain ignition. The forward seating of the RIR valve aligns its intake port **88** with the port **66** serving the forward cylinder **84** of the RIR piston. Flow of the gases into this cylinder drives the RIR in its reverse stroke. Acceleration of the RIR in the aft direction maintains the RIR valve in its forward seat throughout the stroke. Gases contained in the aft cylinder **76** are exhausted through the exhaust port **80** in the RIR valve **60** through ports **92** and **94**, through the chamber **96** surrounding the end of the RIR shaft, and into the ignitor chamber **99** from the axial gas port **97** leading from the chamber **96** at the forward end of the RIR. Debris from the broken glass-container **70** and its contents is blown out through the jet orifices **98**. Preferably, broken pieces larger in size than would conveniently pass through the jet orifices are retained behind filter screen **89** placed as shown in FIG. 3.

Rapid deceleration of RIR **40** as it terminates its reverse stroke throws the RIR valve **60** against its aft seat. Its intake and exhaust ports **82** and **90** respectively are again aligned such that high pressure gases are admitted to the chamber **76** at the aft side of the RIR piston **58** and gases in the chamber **84** at the forward side are exhausted through the jet orifices as before. The RIR accelerates in movement on its forward stroke maintaining the RIR valve against its aft seat. Rapid deceleration of the RIR at termination of its forward stroke throws the RIR valve to its forward seat again. The cycle is repeated; high pressure gases driving the RIR to "jack-hammer" the anchor deeper in penetration of the ocean bottom. It should be noted that the RIR sliding valve **60** may be spring loaded in either the forward or aft direction of its travel as needed if a slow aft or forward stroke is utilized in the inertial cycle of the RIR. Or the weight of the RIR valve **60** may be balanced by spring load if required. The jetting action of the exhaust gases through orifices **98** breaks up and loosens the compacted bottom material and co-operates with the inertial means by facilitating bottom penetration.

When all available energy from the propellant grain has been utilized in placing the anchor, it is in a position with its longitudinal axis substantially vertical, at the required penetration depth in the ocean bottom. In order to achieve its maximum holding force the anchor member must be keyed into a position with its longitudinal axis substantially horizontal. In this position the total fin area plus the projected area of the anchor body bear against the ocean bottom material to resist the strain load in the mooring cable.

In order to secure permanency of the mooring once the anchor has been placed, it is required that the mooring cable must not chafe on the ocean bottom material, and that as the mooring swings with the tides or winds the cable must not work in the bottom material so as to dig out the embedded anchor. The anchor device which is the subject of this invention utilizes the embedment anchor reactor head **4** and barrel **46** as bearing surfaces contiguous with the ocean bottom material in order to distribute the load in the mooring cable over a larger area of ocean bottom material thereby securing lighter unit loads on this material. The mooring cable is itself protected from chaffing against the abrasive ocean bottom material by shrouding it at the point of entry into the ocean bottom. A fair-lead for the mooring cable in all azimuth directions is provided where it enters its shroud at the ocean bottom. The reactor barrel **46** provides the protecting shroud for the mooring cable and the reactor breech obturator nozzle **5** provides the fair-lead for the mooring cable.

In order to effect this economy of parts the following device is employed: The mooring cable **2** is drawn through the obturator breech nozzle **5** as the anchor member and reactor member separate during the ballistics phase, and is subsequently snagged by the loop in the end of the anchor cable **10**. The loop in the end of the anchor cable is passed around the reactor barrel **46** prior to assembling

the anchor to the reactor. FIG. 1 shows the assembly of the anchor cable **10**. One end of this cable is attached to the shackle eye **13** on the reactor member. The loop end is drawn through the shackle eye **12** on the anchor body and passed over the reactor barrel **46** as shown in the figure. The free length of the cable is gathered or coiled and lightly tied in about equal lengths on each side of the anchor shackle eye **12** in such a manner that it will break the tie and pull out to its full length easily without kinking or twisting. The loop in the end of the anchor cable may be lightly tied on the reactor shackle eye **13** so as to maintain its position on the reactor barrel **46** until it is drawn off the reactor barrel just prior to the inertial and jetting phase of penetration when the anchor cable becomes taut and breaks the tie at the reactor shackle eye.

The loop in the end of the anchor cable may be a slip-knot having the cable bent to a permanent set at the extremity of the loop so that the loop will become closed as it passes over the end of the reactor barrel **46**. The closed loop configuration of the anchor cable end will facilitate its snagging the expander ring **7** and the sabot **6** as it passes off the end of the reactor barrel.

The mooring cable **2** immediately above the reactor member includes four components. These are: (1) the stub line **2***c*, or short section of cable to which the obturator nozzle plug **3** is swaged, (2) the slack portion **2***b*, (3) the halter **2***d*, and (4) the greater length of mooring line **2***a*, with which the anchor is lowered to the ocean bottom from the vessel laying the mooring. The halter **2***d* spans between the two ends of the slack line **2***b* and is made just strong enough to support the gross weight of the anchor assembly. During the ballistics phase of anchor penetration the halter **2***d* breaks permitting the breech obturator nozzle throat plug **3** to be drawn through the breech obturator nozzle **5** followed by a portion of the slack line **2***b*.

A portion of the stub line **2***c* extends beyond the inboard end of the obturator nozzle throat plug and is fastened to the RIR sabot **6** by the swage bead **8** as shown in FIG. 2. The RIR sabot **6** is shown in section in FIG. 2 and also in detail in FIG. 2*a*. Holes are drilled through the web of the sabot, the number and size of which are such as to effect the required pressure drop across the face of its web in order to ensure its being retained contiguous with the RIR shaft face as it traverses and subsequently exits the reactor bore. Additionally, tension screws **19** may be used to secure the sabot to the RIR shaft. These tension screws are designed to break under load subsequent to separation of the anchor from the reactor. The RIR sabot **6** and expander ring **7** are designed to retain the combustion gases from exiting through the clearance between the reactor barrel **46** and the RIR shaft **40**. Thus manufacturing tolerances of these bores need not be as close as would otherwise be required. It should be apparent that the total hole area through the web of the sabot should exceed the throat area of the check valve nozzle **91**. Also, the gas passage area around the check valve ball **93** should exceed the throat area of the check valve nozzle **91**. The throat area of the check valve nozzle **91** is made such that the gas flow rate through this nozzle during the burning period up to the time of separation will provide gas at the desired pressure to the secondary propulsion chamber **74**.

The RIR sabot **6** is nominally retained to the RIR shaft by the light tension screws **19** until the initiation of the inertial and jetting phase of anchor embedment. The reciprocating motion of the RIR shaft **40** overloads these light screws and they break under this load if they have not broken previously as the sabot exits the reactor bore and the expander ring **7** extends and subsequently engages the ocean bottom material during anchor penetration. The expander ring **7** may be constructed of laminated steel leaves brazed or welded together at the mid-length and drilled at this section to receive fastener pins or rivets. This construction renders a highly flexible ring which can be made to extend considerably beyond the diameter of the sabot **6** when released. The outer leaf should be thick enough so that it will be positively retained by the sabot ring lands when compressed to enter the bore of the reactor barrel **46**. The leaves may be so arranged that they interleave at their open ends and thus form a good gas seal. The expander ring **7** should be made to have maximum strength consistent with its required degree of expansion. The purpose in providing a sabot ring which will expand when released from its bore is to aid the sabot in snagging the closed loop in the end of the anchor cable, and also to prevent the sabot from being drawn back into the reactor barrel.

FIGS. 4 through 9 illustrate the anchor embedment operation. FIG. 4 shows the anchor assembly being lowered to the ocean bottom.

FIG. 5 shows the anchor assembly striking the ocean bottom material. It will be seen from the figure that the halter line **2***d* spans between the two ends of the slack line **2***b*, supporting the gross weight of the anchor assembly. Slack line **2***b* may be coiled or gathered and loosely tied, so that it does not become entangled with the other mooring line components, or the anchor assembly. If coiled, it should be done in such a manner that the cable does not become twisted or kinked upon release.

As the anchor nose strikes the ocean bottom, trigger pin **30** is depressed against the action of spring **32** breaking the glass container **70** and subsequently igniting the fuse cord **36** as described above. The fuse cord ignites the propellant grain **38** which initiates the ballistics phase of anchor embedment. Burning of the propellant grain produces gases at high pressure and high temperature. Initiation of burning of the propellant produces a shock wave which travels through the breech obturator nozzle **5** and fractures the frangible barrel **1**. This shock wave travels the length of air cavity formerly contained by the barrel **1** and is reflected by the water mass at the far aft end of the cavity. The reflected wave reinforces subsequent pressure waves from the nozzle **5** and the resulting complex wave system is radiated outward into the water medium diagonally and symmetrically from the variable nozzle throat plug **3** as a center line. Subsequent flow of the combustion gases out through the obturator nozzle **5** enters this cavity and forms a bubble under considerable pressure which grows in size from the free volume of the original air cavity to fill the cupped surface formed by the rearward face of the reactor head **4**. The high exhaust pressure, or back pressure, at the nozzle exit causes the exhaust gases to diffuse rather than to go supersonic thus the pressure is maintained at a high value as the bubble grows. The hot gases at the gas-water interface give up their heat energy to a portion of the surrounding water which flashes off into steam and further builds the pressure in the bubble. The entire mechanism is highly transient and cannot be considered to be steady state in any sense, however, the net effect is to provide a great pressure difference across the face of the reactor head **4** during the minute fraction of a second that the impulse is applied to reactor member **43** to drive the anchor member **21** into the ocean bottom during the ballistics phase of anchor operation. This pressure difference acting over the area of the reactor head **4** provides a portion of, or perhaps, the total force required to react the impulse of the shot. Indeed it may provide a force greater than that required to exactly react the shot impulse. In this case the reactor member would be driven forward along with the anchor member. With careful design of the reactor head size the desired motion of the reactor may be obtained, forward or aft. For example, it might be desired that the reactor member be provided sufficient forward motion that its barrel **46** enters the hole immediately following anchor penetration.

During burning of the propellant, combustion gases simultaneously flow through the holes in the web of the RIR sabot **6**, through the choking nozzle **91**, around the check valve ball **93**, through the bore **95** of the RIR shaft **40**, through ports **42** and into the secondary propul-

sion chamber 74. Tension strap 100 is sized so that this strap breaks when secondary propulsion chamber pressure has built up to the designed value. The function of this strap is to maintain the anchor member and reactor member in their initial mated position until the design gross accelerating thrust has been attained. The strap breaks at this condition and permits separation of the anchor member from the reactor member under design conditions only.

Gas pressure acting on the RIR sabot 6 drives the sabot and the RIR shaft from the reactor barrel bore. The mooring cable stub line 2c together with the obturator nozzle plug 3 swaged to it are drawn through the obturator nozzle 5 metering the outflow of gases through this nozzle to maintain the primary propulsion chamber pressure constant as described above. Upon exit of the RIR sabot 6 from the reactor barrel 46 the expander ring 7 extends and prevents the sabot 6 from re-entering its bore due to any circumstance which might apply tension to the mooring cable prior to the keying operation.

FIG. 6 shows the anchor member 21 separated from the reactor member 43 immediately subsequent to the ballistics phase and just prior to the inertial and jetting phase. The anchor member at this point has penetrated the ocean bottom to a considerable depth. At some point prior to the inertial and jetting phase tension on the loop side of the anchor cable 10 breaks the loop tie and permits the loop to slip off the reactor barrel 46 and snag the sabot 6. Further anchor penetration draws the mooring cable 2 which is slack through the reactor barrel. The point at which the loop tie breaks may be controlled by the length of anchor cable 10 drawn through the anchor shackle eye 12 and the strength of the tie and may be determined on test.

FIG. 7 shows the anchor during the inertial and jetting phase of penetration. The anchor continuous to penetrate the ocean bottom material during this phase of its operation. It draws additional slack mooring cable as required through the reactor barrel 46 as it proceeds to its maximum penetration depth.

FIG. 8 shows the anchor being keyed into the horizontal position in which position its fin area will lie in the horizontal plane. To accomplish this final operation it is only required to apply tension to the mooring cable 2a at the surface end of an amount equal to the holding force required of the mooring. The result of applying tension to the mooring cable to key the anchor member 21 is the following: As the mooring cable becomes taut the reactor barrel 46 is aligned with the hole in the ocean bottom regardless of its former position. As the mooring cable is drawn to the surface under constant load the reactor barrel 46 is drawn into the bottom hole by the action of the anchor cable 10 as it slips through its shackle eye 12 at the anchor member and applies the tension in its length to the shackle eye 13 at the reactor member. The reactor member acting under this load is drawn into the bottom hole to a point where the reactor head 4 becomes securely seated on the ocean floor. Continued load applied to the mooring cable keys the anchor into the horizontal plane.

To facilitate keying of the anchor the trailing edges of the anchor fins 20 are cut and slotted as shown in FIG. 2. The slots 106 are cut almost through the thickness of the fin material on the opposite side of the fins 20 from the anchor shackle 12 as shown in section A—A. When keying tension is applied to the mooring cable, the anchor is drawn back slightly toward the bottom surface. In so doing, the bottom material bears against the trailing edge of the anchor fins 22 (now the leading edge) and causes the trailing portion of the fins to bend as shown in section A—A. These flap portions 22 of the fins 20 bend easily until the upper edges of the slot 106 come together. Compression of the fin material at this point and tension in the material at the thin bent portion at the bottom of the slot prevent the fin flaps from any further bending. Thickness and depth of the slot thus determines the angle through which the flaps will bend. The bend flap portions of the fins act together with the offset anchor shackle eye 12 to key the anchor with a minimum required pullout. The fin rib 101 prevents possible bending of the flaps in the wrong direction.

FIG. 9 shows schematically the anchor member 43 and the reactor member 21 in their final keyed positions. With the anchor keyed into position, it is ready to be integrated into the mooring system, and is subsequently put into service.

In order to satisfy the requirement for brevity the Abstract of the Disclosure is necessarily incomplete, and therefore is not to be construed in any way as defining or limiting the scope of the invention.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly all suitable modifications and equivalents may be resorted to, falling within the scope of the invention as claimed.

What is claimed as new is as follows:

1. An embedment anchor for anchoring to a body of material including, an anchor member adapted to be driven into and anchor within said body of material, and said embedment anchor utilizing a combination of, ballistics driving means, and reciprocative inertial driving means for driving said anchor member into said body of material.

2. An embedment anchor as claimed in claim 1, said embedment anchor including erosive jetting means for driving said anchor member into said body of material.

3. An embedment anchor as claimed in claim 1, said ballistics driving means comprising, said anchor member, a reaction member mated with said anchor member and said anchor member being movable relatively to said reaction member in a direction away from said reaction member, propulsion means disposed between said anchor member and said reaction member to provide force acting on the anchor member and the reaction member to propel the anchor member away from said reaction member and to drive said anchor member into said body of material, and said inertial driving means comprising said anchor member and a reciprocating inertial reaction member as part of said anchor member, propulsion means in said anchor member propelling said reciprocating inertial reaction member in a reciprocating motion relatively to said anchor member whereby said anchor member is driven into said body of material.

4. An embedment anchor as claimed in claim 3, said embedment anchor including jetting means comprising an orifice as a part of said anchor member adapted to direct a high velocity jet stream against said body of material thereby rapidly eroding and breaking up the compacted material of said body of material to facilitate penetration into said body of material by the anchor member under the driving action of said inertial driving means.

5. An embedment anchor for anchoring to a body of material including, an anchor member adapted to be driven into and anchor within said body of material, and said embedment anchor utilizing a combination of, ballistics driving means, and erosive jetting means for driving said anchor member into said body of material.

6. An embedment anchor as claimed in claim 5, said ballistics driving means comprising, said anchor member, a reaction member mated with said anchor member and said anchor member being movable relatively to said reaction member in a direction away from said reaction member, propulsion means disposed between said anchor member and said reaction member to provide force acting on the anchor member and the reaction member to propel the anchor member away from said reaction member and to drive said anchor member into said body of

material, and said jetting means comprising a nozzle as a part of said anchor member adapted to direct a high velocity jet stream into and against said body of material thereby rapidly eroding and breaking up and dispersing the compacted material of said body of material, said anchor member displacing said broken up and dispersed flocculent material by the action of gravity on said anchor member and said broken up material.

7. An embedment anchor for anchoring a load to a body of material comprising, an anchor member adapted to anchor within said body of material, a reaction member mated with said anchor member and said anchor member being movable relatively to said reaction member in a direction away from said reaction member, propulsion means to provide force acting on the anchor member and the reaction member to propel the anchor member away from said reaction member, and said reaction member including an enlarged reaction portion which rearward face thereof is acted upon by high pressure gas to generate a pressure reaction opposing the force of the propulsion means on the reaction member for propulsion of the anchor member away from the reaction member and into said body of material.

8. The embedment anchor of claim 7, and means securing said anchor member to said reaction member adapted to be broken by the force of said propulsion means to release the anchor member from the reaction member.

9. An embedment anchor as claimed in claim 7 in which includes a cable spanning between the anchor member and the load and affixed to both the anchor member and the load, means protecting said cable comprising said reaction member for providing a protective shroud for said cable at its point of entry into said body of material, said cable protecting means co-operating to provide footing contiguous with and against a relatively larger area of material of said body of material than would be possible if the cable alone were to bear against said body of material, said cable protecting means including a portion of the reaction member having a configuration such as to provide a fair-lead for said cable in every direction wherein said load may direct said cable.

10. An embedment anchor for anchoring to a body of material comprising, an anchor member adapted to anchor within said body of material, a reaction member mated with said anchor member and said anchor member being movable relatively to said reaction member in a direction away from said reaction member, propulsion means producing gas at high pressure to provide force acting on the anchor member and the reaction member to propel the anchor member away from said reaction member and into said body of material, means operable to retain for a period of time relatively longer than the time for separation of the anchor member from the reaction member a portion of said high pressure gas within said anchor member at separation of the anchor member from the reaction member, penetration means to utilize efficiently the energy remaining to the said retained high pressure gas to provide further penetration of the anchor member into said body of material.

11. An embedment anchor as claimed in claim 10 in which said penetration means comprises a reciprocating inertial reaction member together with high velocity gas exhaust nozzles as parts of said anchor member to provide further penetration of the anchor member into said body of material subsequent to initial penetration into said body of material provided by said propulsion means.

12. An embedment anchor as claimed in claim 10 in which said penetration means comprises a reciprocating inertial reaction member as a portion of said anchor member, said reciprocating inertial reaction member being driven by the retained high pressure gas in a reciprocating motion to provide further penetration of the anchor member into said body of material subsequent to initial penetration into said body of material provided by said propulsion means.

13. An embedment anchor as claimed in claim 10 in which said penetration means comprises an orifice adapted to direct a high velocity gas jet stream against said body of material thereby rapidly eroding and breaking up the compacted material of said body of material to facilitate penetration of the anchor member into said body of material.

14. In a ballistics device a projectile member, a reaction member mated with said projectile member, said projectile member adapted to move relatively to said reaction member, a chamber formed by the reaction member and the projectile member and disposed between the reaction member and the projectile member, the volume of said chamber increasing as the projectile member moves relatively to the reaction member, propulsion means producing gas at internal ballistics pressures, said gas acting in said chamber to provide force acting on the projectile member and the reaction member to propel the projectile member relatively to and away from the reaction member, and regulating means for maintaining the pressure of said gas substantially invariable throughout the period of said relative movement of the projectile member and the reaction member prior to the point of separation of the projectile member from the reaction member.

15. A ballistics device as claimed in claim 14 in which said means for maintaining the pressure of said gas acting in said chamber constant comprises, an opening in said chamber, a plug having a length bearing a define relation to the distance traversed by the projectile member relative to the reaction member up to the point of separation of the projectile member from the reaction member and a lateral dimension which is a variable dependent upon the point selected along its length, said plug adapted to be moved through said opening whereby the outlet of said opening is varied in size dependent upon the relative position of the plug with respect to the opening, and said plug being maintained in continuous translational relationship to said projectile member during movement of said projectile member relative to said reaction member up to the point of separation of said projectile member from said reaction member, said lateral dimension of said plug at each point along its length being such that the instantaneous size of the outlet of said opening is just sufficient under thermodynamic conditions existing in said chamber to exhaust from said chamber all excess gas production over that which is required of said propulsion means to provide gas at a high constant chamber pressure under the conditions and circumstances of dynamic response of the projectile member and the reaction member to said propulsion means, said propulsion means producing gas at the desired chamber pressure at a rate equal to, or exceeding, the maximum requirements of said ballistics device.

16. In a ballistics device a projectile member, a reaction member mated with said projectile member, said projectile member adapted to move relatively to said reaction member, a plurality of chambers formed by the projectile member and the reaction member and said chambers disposed between portions of the projectile member and the reaction member, the volumes of said chambers increasing as the projectile member moves away from the reaction member, propulsion means pro- chambers for reducing the pressure of said gas in succeeding chamber respectively to a value compatible with each particular chamber diameter and structural limitation, said high pressure gas acting in each of said chambers to provide force acting on the projectile member and the reaction member to propel the projectile member away from said reaction member.

17. A ballistics device as claimed in claim 16 having in combination, working seals for providing a barrier to the flow of said high pressure gas beyond said seals in said chambers, said seals comprising a porous material

having its voids filled with a high temperature-resistant lubricating material, said working seals adapted to be mated with said chambers and to conform to the cross sectional configuration of said chambers and be a close fit to the walls of said chambers.

18. In a ballistics device a projectile member, a reaction member mated with said projectile member, said projectile member adapted to move relatively to said reaction member, a chamber formed by the reaction member and the projectile member and disposed between the reaction member and the projectile member, the volume of said chamber increasing as the projectile member moves relatively to the reaction member, propulsion means producing gas at high pressure, said gas acting in said chamber to provide force acting on the projectile member and the reaction member to propel the projectile member relatively to and away from the reaction member, and means comprising an opening in said chamber, said opening being variable in size, whereby excessive gas production from said propulsion means is exhausted so as to maintain said gas acting in said chamber at a high constant pressure throughout the period of said relative movement of the projectile member and the reaction member prior to the point of separation of the projectile member from the reaction member.

19. The embedment anchor of claim 2 comprising, said anchor member, a reaction member, a chamber disposed between said anchor member and said reaction member, ignitable propulsion means in said chamber operable to propel said anchor member into a bottom of a body of water upon contact therewith, ignition means comprising a plunger, a sealed frangible container, a chemical material contained in said frangible container which when exposed to water reacts with said water to produce a violent exothermic chemical reaction, a fuse ignitable by said exothermic chemical reaction and disposed between said frangible container and said ignitable propulsion means, means ducting a portion of the water of said body of water to a location contiguous with the sealed frangible container upon immersion of the embedment anchor in the body of water, said plunger adapted to break the frangible container upon contact of the anchor member with the bottom of the body of water exposing said chemical material to the water of said body of water whereby said ignitable propulsion means is ignited.

20. An embedment anchor for anchoring a load to a body of material comprising, an anchor member adapted to anchor within said body of material, a reaction member mated with said anchor member and said anchor member being movable relatively to said reaction member in a direction away from said reaction member, propulsion means to provide force acting on the anchor member and the reaction member to propel the anchor member away from said reaction member and into said body of material, a cable spanning between the anchor member and the load and affixed to both the anchor member and the load, cable protecting means to provide a protective shroud for said cable at its point of entry into said body of material, said cable protecting means co-operating to provide footing contiguous with and against a relatively larger area of material of said body of material than would be possible if the cable alone were to bear against said body of material, said cable protecting means also cooperating to provide a fair-lead for said cable in every direction wherein said load may direct said cable.

21. An embedment anchor for anchoring a load to a body of material comprising, an anchor member adapted to anchor within said body of material, a reaction member mated with said anchor member and said anchor member being movable relatively to said reaction member in a direction away from said reaction member, propulsion means to provide force acting on the anchor member and the reaction member to propel the anchor member away from said reaction member and into said body of material, fins disposed laterally in an axial direction along the body of said anchor member, means facilitating keying of said anchor member comprising a flap portion of said fins, a slot in said fins, said flap portion adapted to bend at said slot and rotate relatively to said fins to a certain fixed angular limit upon application of said load whereby said anchor member is caused to rotate with minimum pullout into a substantially horizontal or keyed position in which the anchor member is better able to resist the strain of said load.

22. An embedment anchor for anchoring to a body of material comprising, an anchor member adapted to anchor within said body of material, a reaction member mated with said anchor member and said anchor member being movable relatively to said reaction member in a direction away from said reaction member, a chamber formed by the anchor member and the reaction member and disposed between the anchor member and the reaction member, the volume of said chamber increasing as the anchor member moves away from the reaction member, propulsion means producing gas at high pressure, said gas acting within said chamber to provide force acting on the anchor member and the reaction member to propel the anchor member away from the reaction member, said reaction member including an enlarged reaction portion, means adapted to cause a portion of said gas to be exhausted from said chamber during movement of the anchor member away from the reaction member prior to the point of separation of the anchor member from the reaction member, and said exhausted portion of high pressure gas acting on the rearward side of the enlarged reaction portion of the reaction member to generate a gas pressure reaction opposing the force of the high pressure gas in said chamber acting on the reaction member for propulsion of the anchor member away from the reaction member and into said body of material.

23. An embedment anchor as claimed in claim 22, and said means adapted to cause a portion of said gas to be exhausted from said chamber comprises an opening in said chamber, said opening being variable in size whereby the portion of high pressure gas exhausted therefrom is regulated so as to maintain the pressure of said gas acting within said chamber substantially constant during relative movement of the anchor member away from the reaction member prior to the point of separation of the anchor member from the reaction member.

24. A ballistics device as claimed in claim 17 in which said seals include, an obturating member, an impregnated porous member comprising said porous material and said lubricating material, said impregnated porous member being affixed to that side of the obturating member which faces said high pressure gas, said obturating member having substantially the same radial dimensions and peripheral configuration as said impregnated porous member.

25. A ballistics device as claimed in claim 24 in which said seals include rings and have two radially defined working surfaces, one of said working surfaces facing outward and the other facing inward, and said obturating member having lands and groves on both said working surfaces with said rings retained therein.

26. An embedment anchor as claimed in claim 10, and said means operable to retain a portion of said high pressure gas within said anchor member comprising a working seal, said reaction member including said working seal as a part thereof, said working seal moving together with said reaction member during relative movement between the anchor member and the reaction member, said anchor member adapted to retain said working seal at separation of the anchor member from the reaction member thereby retaining said high pressure gas behind said working seal within said anchor member.

27. An embedment anchor as claimed in claim 10, and said means operable to retain a portion of said high pressure gas within said anchor member comprising a one-way flow gas check valve as a part of said anchor member.

28. An embedment anchor as claimed in claim 20, and said cable protecting means comprises said reaction member.

29. An embedment anchor for anchoring to a body of material comprising, an anchor member adapted to anchor within said body of material, a reaction member mated with said anchor member and said anchor member being movable relatively to said reaction member in a direction away from said reaction member, a chamber formed by the mated anchor and reaction members and disposed between the anchor member and the reaction member, propulsion means producing gas at high pressure, said gas acting in said chamber to provide force acting on the anchor member and the reaction member to propel the anchor member away from the reaction member, said chamber having an opening adapted for passage of a desired proportion of said gas therefrom, said reaction member including an enlarged reaction portion, and said proportion of high pressure gas passing from the opening in said chamber acting on the rearward face of the enlarged reaction portion of the reaction member to generate a gas pressure reaction opposing the force of the high pressure gas in said chamber acting on the reaction member for propulsion of the anchor member away from said reaction member and into said body of material.

30. An embedment anchor as claimed in claim 3, and said propulsion means for propelling the reciprocating inertial reaction member comprising a gas under high pressure, said reciprocating inertial reaction member including a free sliding gas valve adapted to be seated in the reciprocating inertial reaction member in one of two possible positions depending on the direction of accelerated motion of the reciprocating inertial reaction member, in each of said positions said gas valve directing the flow of said gas to act on the reciprocating inertial reaction member to provide force accelerating the reciprocating intertial reaction member in the direction to maintain said gas valve in its respective position, said gas valve being caused to change position upon deceleration of the reciprocating inertial reaction member at the termination of its stroke, whereby said reciprocating inertial reaction member is propelled

in a reciprocating motion relatively to said anchor member.

31. An embedment anchor as claimed in claim 30, and said free sliding gas valve being adapated to duct the exhaust of said gas from its location of action on the reciprocating inertial reaction member to and through an orifice located in the forward portion of said anchor member, said gas passing from said orifice at high velocity, and therefrom said gas being directed against said body of material thereby rapidly eroding and breaking up the compacted material of said body of material to facilitate penetration into said body of material by the anchor under the driving action of said reciprocating inertial reaction member.

32. An embedment anchor for anchoring to a body of material comprising, an anchor member adapted to anchor within said body of material, a reaction member mated with said anchor member and said anchor member being movable relatively to said reaction member in a direction away from said reaction member, an open chamber formed by the mated reaction and anchor members and disposed between the reaction member and the anchor member, propulsion means in said open chamber adapted to act between the anchor member and the reaction member to provide force acting on the anchor member and the reaction member to propel the anchor member away from the reaction member, said reaction member including an enlarged reaction portion, said propulsion means producing gas at high pressure, said open chamber adapted to exhaust a portion of gas through the opening thereof during movement of the anchor member away from the reaction member prior to the point of separation of the anchor member from the reaction member, and said portion of high pressure gas acting on the rearward side of the enlarged reaction portion of the reaction member to generate a gas pressure reaction opposing the force of the propulsion means on the reaction member for propulsion of the anchor member away from the reaction member and into said body of material.

References Cited

UNITED STATES PATENTS

940,003	11/1909	Larsen	102—10 X
3,032,000	5/1962	Feller	114—206
3,170,433	2/1965	Gardiner	114—206

TRYGVE M. BLIX, Primary Examiner

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,520,268 Dated July 14, 1970

Inventor(s) Bernal L. Bower, 2972 Pemba Dr., Costa Mesa, Calif.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 34, "gap" should read --gas--.
Column 4, line 20, "swagiing" should read --swaging--.
Column 7, line 4, "of example" should read --for example--.
Column 7, line 49, "cooperating" should read --co-operating--.
Column 8, line 3, "port 88" should read --port 86--.
Column 11, line 36, "continuous" should read --continues--.
Column 12, line 2, "bend" should read --bent--.
Column 14, line 31, "define" should read --definite--.
Column 14, line 65, following the words "propulsion means" strike out "pro-" and insert in place thereof --producing gas at high pressure, means connecting said--.
Column 14, line 66, following the words "of said gas in" insert the word --each--.
Column 15, line 65, "cooperating" should read --co-operating--.
Column 18, line 13, following the word "anchor" the word --member-- should be inserted.

SIGNED AND
SEALED
DEC 29 1970

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE 1969 O—366-334