United States Patent [19]

Walthier et al.

[11] **3,750,547**

[45] **Aug. 7, 1973**

[54] **FREE FALL BOTTOM SAMPLER**

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[22] Filed: **Oct. 16, 1970**

[21] Appl. No.: **81,222**

Related U.S. Application Data

[62] Division of Ser. No. 711,792, March 8, 1968, Pat. No. 3,572,129.

[52] **U.S. Cl.** ..... **95/11 UW**

[51] **Int. Cl.** **G03b 17/08**

[58] **Field of Search** ..... 351/43; 350/179, 350/180, 175 SL; 95/11 W, 11; 200/84

[56] **References Cited**

UNITED STATES PATENTS

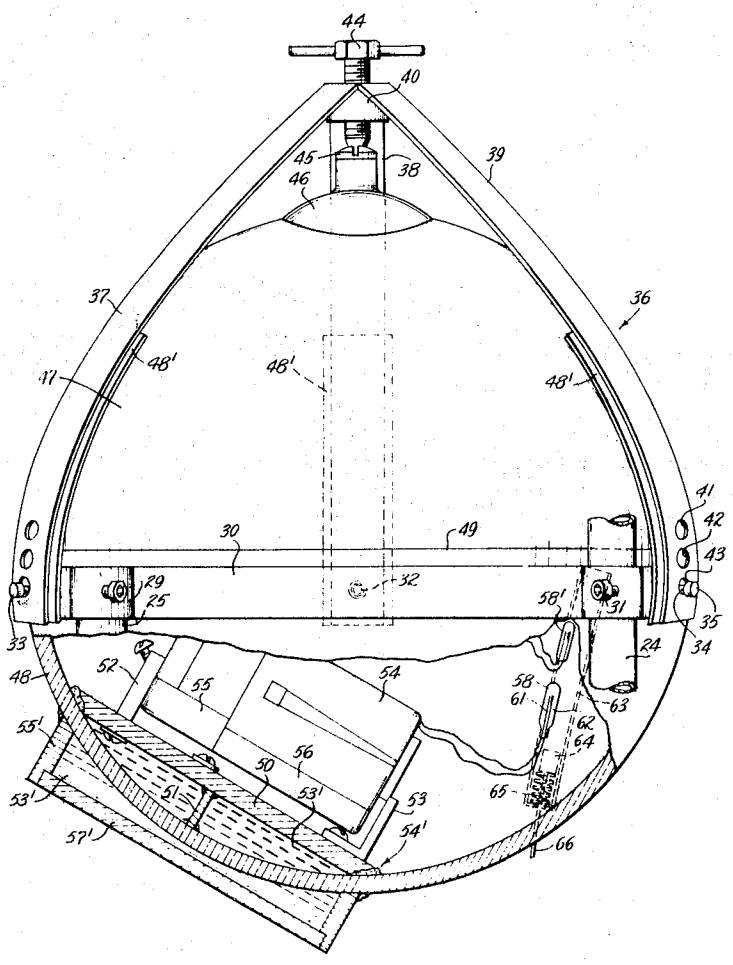
3,084,433	4/1963	Kaatz	350/175
3,558,220	1/1971	Werner	350/021
3,261,274	7/1966	Smith	95/11
2,249,418	7/1941	Chambers	200/84
2,784,273	3/1957	Binford	200/84

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[57] **ABSTRACT**

A bottom sampler to obtain a sample of the bottom of a body of water. A pair of clam shell jaws are pivotally connected to the base of an upright frame of the sampler. Hollow buoyant spheres are retained within the upright portion of the frame. The jaws are latched in an open position against the bias of resilient elements which close the jaws when the latch is released in response to impact with the bottom. Two weights, one on the back of each jaw stabilize the sampler during descent and fall off when the jaws close. A camera located within one of the hollow spheres photographs the bottom of the body of water from which the sample is taken. A unique signal-flare and smoke producing device automatically actuated when the sampler returns to the surface. Other day or night signal devices such as a radio or flasher can also be used and provision is made to attach such devices to the sampler.

15 Claims, 12 Drawing Figures



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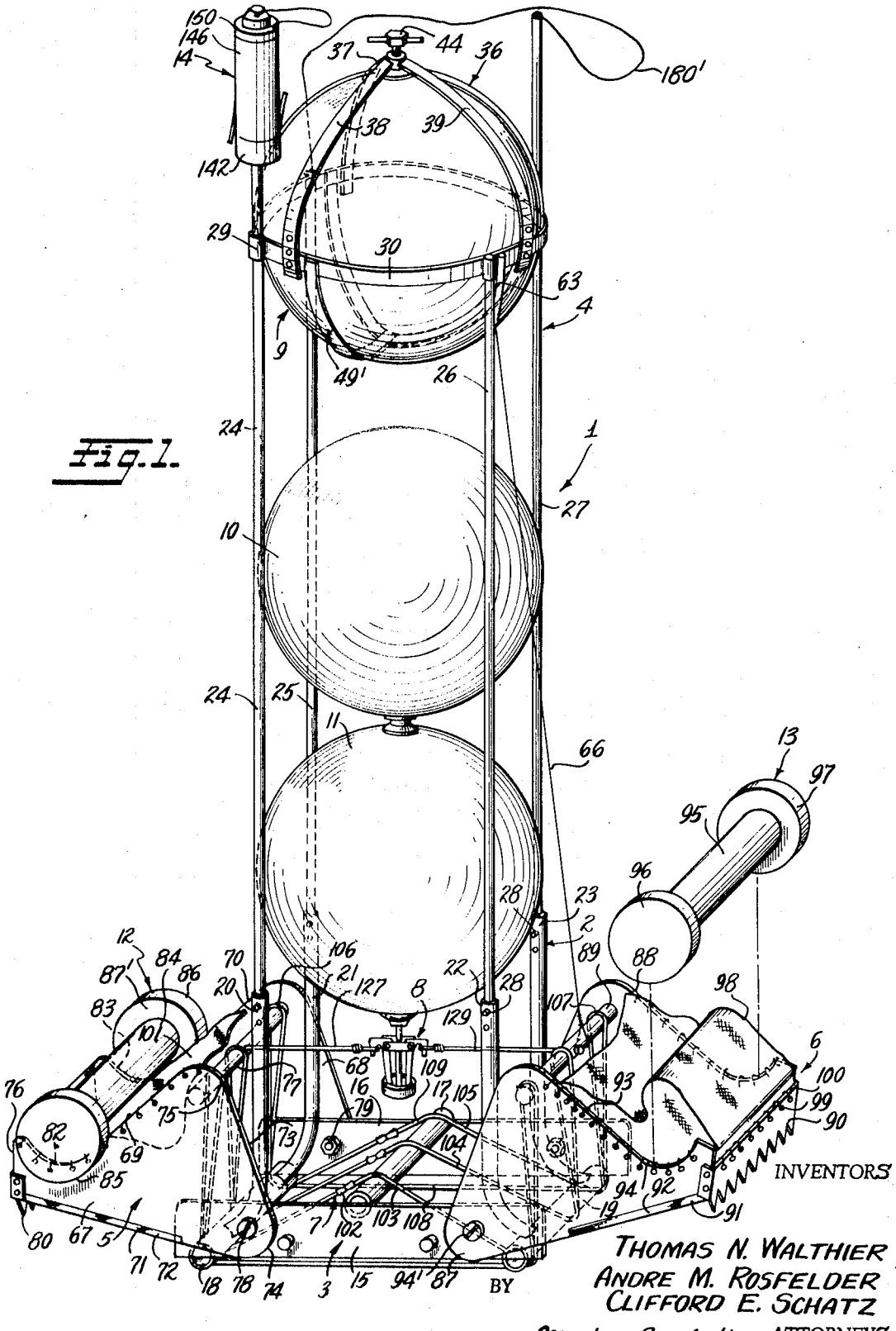


Fig. 1.

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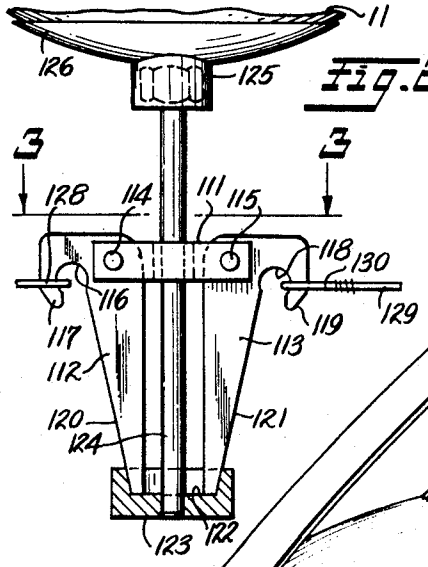


Fig. 2.

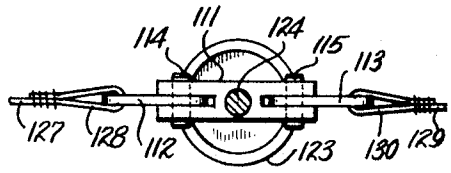


Fig. 3.

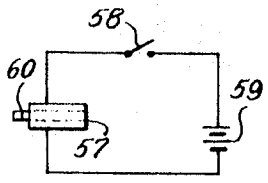


Fig. 12.

Fig. 4.

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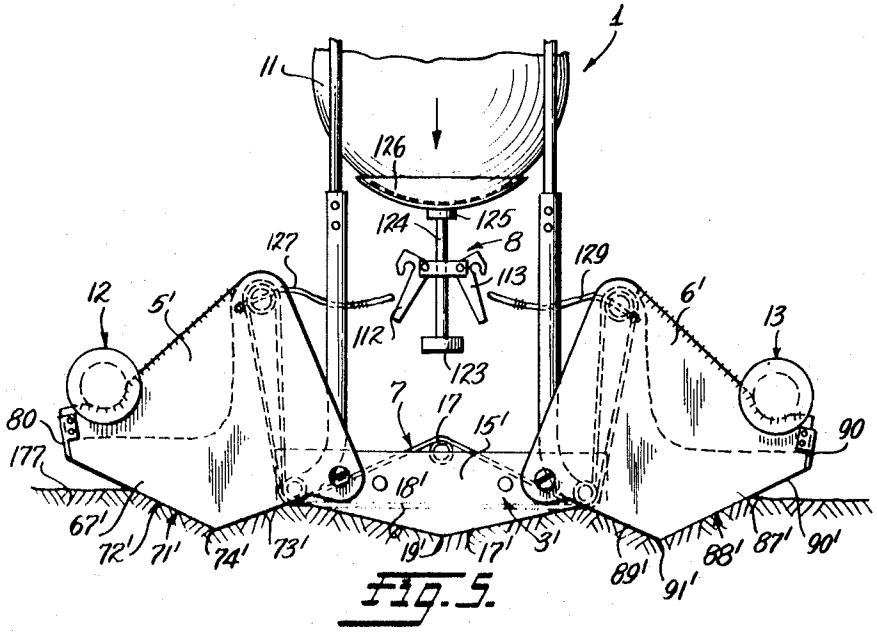


Fig. 5.

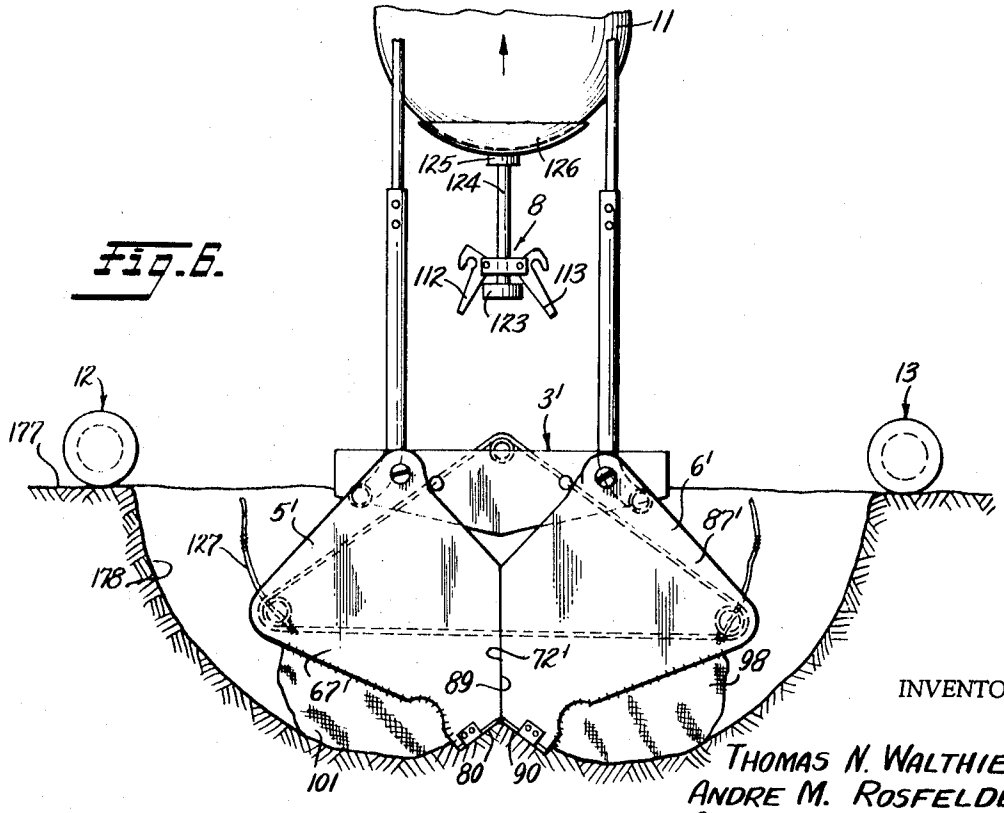


Fig. 6.

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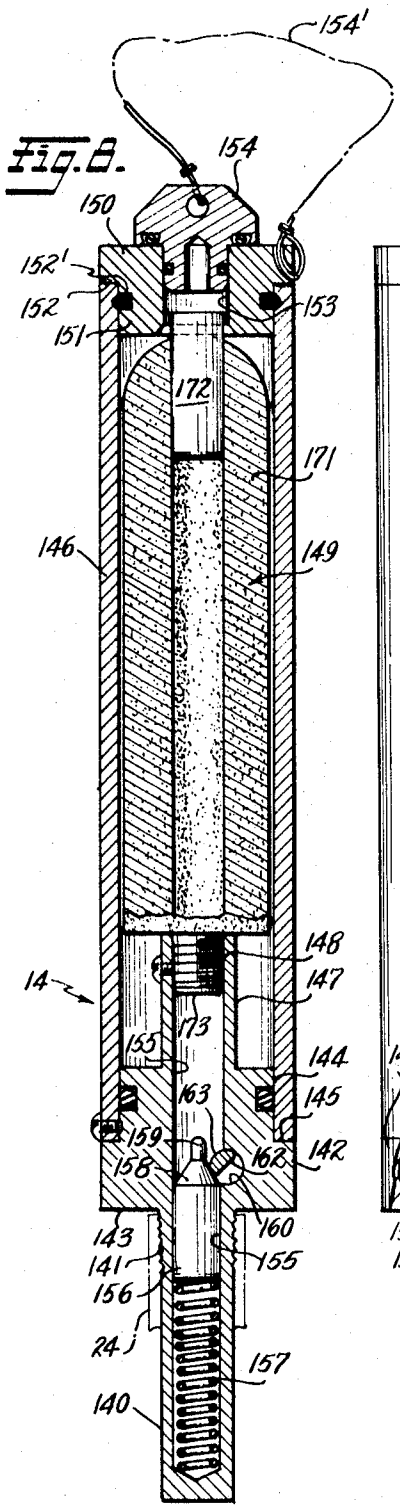
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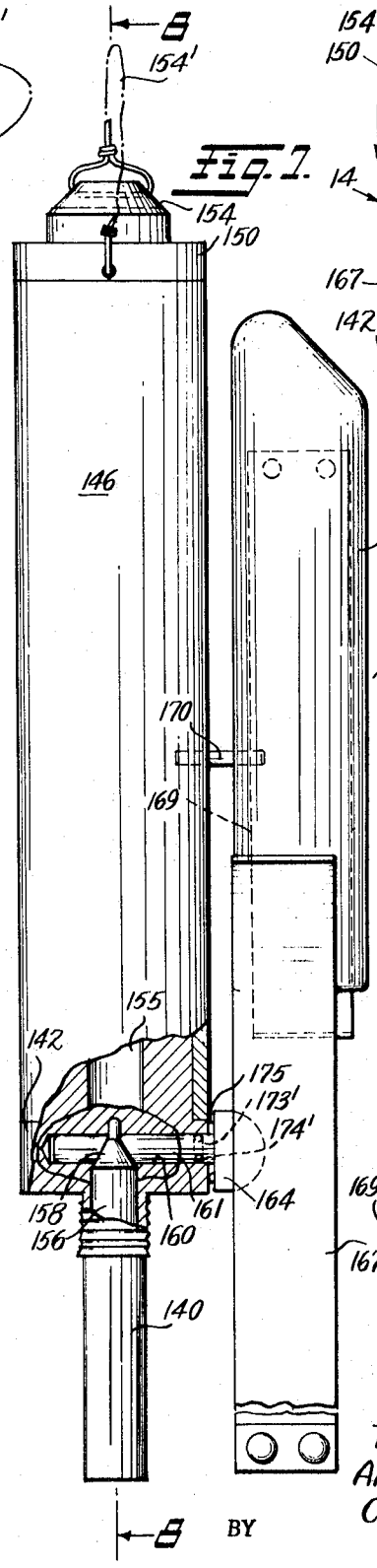
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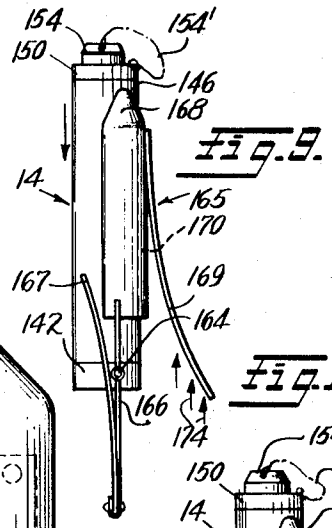
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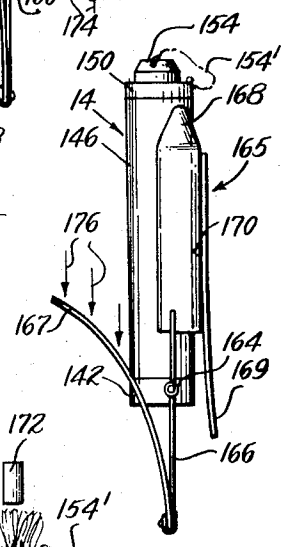
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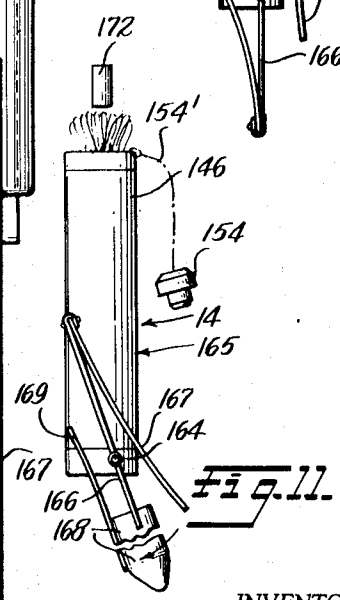
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FREE FALL BOTTOM SAMPLER

This is a division of application Ser. No. 711,792 filed Mar. 8, 1968, now U.S. Pat. No. 3,572,129.

This invention relates generally to a bottom sampler to obtain a sample of the bottom of a body of water, and more particularly to such a sampler of the recoverable free-fall type which does not require a retrieving line between the sampler and the vessel from which it is launched or dropped.

More specifically, the invention relates to a unique free-fall sea bottom sampler having clam shell type jaws which dig into and grab a sample of the bottom and the sampler then returns to the surface of the water with the sample. Although the sampler of this invention has other uses, it is of particular utility for obtaining samples of an ocean bottom to determine the presence of manganese nodules in anticipation of sub-sea mining.

Among the features of the bottom sampler of this invention are a pair of clam shell jaws adjacent the bottom of an upright frame, floatation means in the form of hollow glass or plastic spheres retained by the frame, resilient means to close the jaws to obtain a sample of the ocean bottom, and a latch assembly actuated in response to impact of the bottom sampler with the ocean bottom to release the jaws so they close under the influence of the resilient means. The jaws are so arranged so that the weights which cause the sampler to sink to the bottom, are merely supported on each of the jaws and these weights create force moments which assist the resilient means during initial closing of the jaws. The weights fall off the jaws at an intermediate point during closing and hence, the sampler is returned to the surface by the floatation devices. One of the spheres is transparent and provides a housing for a flash bulb equipped camera to photograph the portion of the ocean bottom from which the sample is taken. The camera is operated in a unique manner.

A significant advantage of the sampler of this invention over the previously known coring type samplers is that this sampler takes a significantly larger sample than these prior known devices. In one embodiment, the back of each jaw of the sampler is completely closed and the entire grabbed sample is retained. In another embodiment, a mesh sack which allows washing out of the fines, extends across the back of each jaw and clean samples of the modules are recovered at the surface.

Additional features and advantages of the bottom sampler includes a structure which sinks in the water in a stable vertical position throughout its travel to the bottom. Such vertical stability is attributable, at least in part, to the location of the ballast weights adjacent the bottom of the sampler and the location of the floatation spheres above the weights. A distinct advantage of the arrangement is that the sampler is actuated to allow the jaws to close wholly by a mechanical system which is completely fool proof. Hence, even if a malfunction occurs the sampler will return to the surface where it can be recovered. Even where the sampler encounters a rough or uneven bottom with substantial slant, at least a small sample is taken and the sampler returns to the surface where it can be recovered. A known disadvantage of the coring type samplers is loss of the sampler where the coring device is driven into the bottom at an angle. Since the sampler of this invention does not rely on a coring tube or other similar device to take the sample its reliability is far better than the prior known devices.

The signal and flare device, which forms a portion of this invention, includes a unique mechanical blocking mechanism to prevent its actuation until the bottom sampler returns to the surface.

Numerous other features and advantages of the bottom sampler of this invention will become apparent with reference to the drawings which form a part of this specification and wherein:

FIG. 1 is a pictorial view of the sampler of this invention;

FIG. 2 is a partial enlarged side elevational view, with portions in section, of the jaw release mechanism;

FIG. 3 is a sectional view taken along lines 3—3 of FIG. 2;

FIG. 4 is a partial side elevational view, with portions thereof broken away, of the upper portion of the bottom sampler of this invention, and shows the mode of mounting a camera in the transparent sphere, and the fluid lens of the sphere;

FIG. 5 is a side elevational view showing a second type of jaw of the sampler, and showing the position of the various parts of the sampler immediately after the jaws are released;

FIG. 6 is a view corresponding to FIG. 5 but showing the jaws closed;

FIG. 7 is a side elevational view of the flare and smoke signal device of the bottom sampler;

FIG. 8 is a sectional view taken along lines 8—8 of FIG. 7;

FIGS. 9–11 are side elevational views of the signal device, with FIG. 9 showing forces acting on the device during descent of the sampler, FIG. 10 showing forces acting on the device during ascent of the sampler, and FIG. 11 showing the signal device actuated; and

FIG. 12 is a wiring diagram of the camera shutter operating circuit of the bottom sampler.

Referring now to the drawings in detail and particularly to FIG. 1, there is shown a sampler 1 constructed in accordance with this invention having a frame 2 including a base 3 and an upright portion or cage 4. Pivotally connected to base 3 are jaws 5 and 6 which are movable from the open position of FIG. 1 to the closed position of FIG. 6.

Jaws 5 and 6 are normally urged to the closed position by a plurality of resilient elements 7 which are advantageously formed from surgical tubing (of the type used in underwater spear guns) because of its high strength and elasticity. Jaw actuating mechanism 8 interconnects the jaws when in the open position of FIG. 1 and maintains the jaws open until the bottom sampler hits the bottom of the body of water from which the sample is to be taken, whereupon the jaws are released, and close in a manner which will subsequently be described in detail.

Disposed within upright portion 4 are hollow spherical buoyant elements 9–11.

Weights 12 and 13 are supported, respectively, on jaws 5 and 6 and cause the bottom sampler to sink to the bottom of the body of water in which it is dropped. The weights fall off when the jaws close to take a sample of the bottom, and the sampler is buoyed upwardly by spheres 9–11 and returns to the surface.

A combined flare and smoke producing device 14 connected to the top of upright portion 4 of the frame

is actuated when the sampler surfaces and provides a signal to assist locating the sampler.

Base 3 is generally rectangular and includes horizontally elongated, upright rectangular side plates 15 and 16 in spaced apart parallel relation to each other and connected together by tubular cross members 17–19 which extend perpendicularly between the side plates. Tubular member 17 is welded at its ends to side plates 15 and 16 at a location adjacent the top edge of the side plates but centrally along their length. Tube 18 is welded to the side plates so it extends slightly below the bottom edge of the plates and is located adjacent one end of the plates. Tube 19 is similarly welded to the side plates adjacent the opposite end of the base. As is seen from FIG. 1, the tubular cross members 17–19 are each parallel with each other, and cross members 18 and 19 are disposed in the same horizontal plane. Tubular members 18 and 19 cooperate with side plates 15 and 16 to provide a base 3 of generally rectangular configuration as viewed in plan.

Welded to tubular cross member 18 and curving inwardly and then upwardly from the tubular member are a pair of tubular connectors 20 and 21 which extend approximately one fourth the height of upright portion 4 of the frame. Connectors 20 and 21 are fixed to tubular cross member 18 by welding and are in spaced apart parallel relation to each other. A second pair of tubular connectors 22 and 23 curve, first inwardly and then upwardly, in the same manner as connectors 20 and 21 and are welded to tubular cross member 19 so they extend upwardly in spaced parallel relation to connectors 20 and 21. The arrangement is such that the upper ends of the connectors form a rectangular array.

Upright portion 4 of the frame includes elongated upright tubes 24–27, the lower ends of which extend respectively into the upper ends of tubular connectors 20–23 and are secured against longitudinal movement by lock pins or screws 28. Each screw 28 extends through the wall of a tubular connector and through the wall of an upright tube to key the tubes to the connector.

The upper ends of upright tubes 24–27 extend through sleeves 29 fixed to a clamping ring 30. Sleeves 29 are secured to the clamping ring with their axes vertical and in the same rectangular array as that of connector tubes 20–23 and are spaced vertically above the connector tubes. It will be observed with reference to FIG. 1 that upright tubes 25 and 26 terminate at the clamp ring whereas tubes 24 and 27 extend a substantial distance above the ring. As shown at FIG. 4, screws 31 threaded into sleeves 29 hold the clamp ring in position on tubes 24–27.

With reference to FIG. 4, three retaining studs 32–34 are fixed to clamp ring 30 and project radially outwardly from the ring in equally spaced circumferential relation to each other. Each retaining stud has an enlarged head 35 by which a clamp assembly 36 is connected to clamp ring 30. Clamp assembly 36 has three equally spaced arms 37–39 having upper ends secured to a threaded boss 40 positioned above the vertical axis of sphere 9. Each arm, generally follows the curvature of sphere 9, has openings 41–43 serially located adjacent the ends of the arms, the several openings of the respective arms each being spaced the same distance from the ends of the arms. Openings 41–43 are each slightly larger than the heads 35 of studs 34. Extending through threaded boss 40 is a clamp bolt 44 which engages a bushing 45 on a resilient suction cup 46 pressed against the upper end of sphere 9. Suction cup 46 acts as a cushion between the sphere and clamp bolt 44 and prevents slipping.

Sphere 9 is comprised of two identical hemispherical shells, including an upper hemisphere 47 and a lower hemisphere 48, which are tightly held together by clamp assembly 36 and clamp ring 30. As shown at FIG. 4, the hemispherical shells abut along a horizontal joint 49. The surfaces of the halves at the joint are smoothly polished. A seal is provided between the abutting surfaces and may take the form of a thin metal or plastic gasket or silicone grease. Clamp ring 30 has an inside diameter slightly less than the diameter of sphere 9 so that lower hemisphere 48 seats in the clamp ring. Thus, when pressure is applied to upper half 47 of sphere 9 by tightening clamp bolt 44 the hemispheres 47 and 48 will be tightly pressed together and sealed against leakage of water into the sphere. By making openings 41–43 slightly larger than the enlarged heads 35 of studs 32–34 it is merely necessary to unthread clamp bolt 44 several turns so that heads 35 of the studs can clear the openings whereupon the arms 37–39 may be flexed outwardly and the clamp assembly 36 removed. Then upper hemisphere 47 can be lifted to open the sphere. Installation of clamp assembly 36 to close the sphere can be accomplished with equal facility. Resilient pads 48′ (FIG. 4) between arms 37–39 and hemisphere 48 provide cushions to prevent damage when clamp assembly 36 is tightened. When the sampler is used in deep water, the high pressures encountered cause sphere 9 to shrink with the result that lower hemisphere 48 may then slip through clamp ring 30. This is prevented by retaining straps 49′ (shown at FIG. 1 only) of which there are three, and which, are welded to clamp ring 30 at equidistantly spaced locations, follow the curvature of lower hemisphere 47, and are joined by welding adjacent the pole of the hemisphere.

Hemispheres 47 and 48 are advantageously formed from relatively thick glass or transparent plastic such as PLEXI-GLASS or LUCITE which have good compressive strength. Mounted in the bottom of hemisphere 47 is a flat transparent plate 50 of circular outline which is cemented to the inside of the hemisphere.

A reinforcing strut 51 with a flat top edge and a curved lower edge conforming to the curvature of the inside of hemisphere 47 extends across the center of plate 50 between the plate and the hemisphere to brace the plate against bending. Mounted on plate 30 is a bracket including clamps 52 and 53 which engage the opposite ends of and hold a camera 54 securely to the plate. Plate 50 is so mounted in hemisphere 48 that the plate extends at an angle of 30° to horizontal when the sampler is in its normal upright position. Lens 55 of camera 54 is parallel with plate 50 and thus, the axis of the lens extends at a 60° angle with horizontal. It will be observed with reference to FIG. 4 that the camera is located essentially mid-way between adjacent upright tubes as well as between straps 49′ and thus, can photograph a portion of the bottom of the body of water from which a sample is taken. Camera 54 advantageously has a self-contained flashbulb unit 56 synchronized with the shutter of the camera to illuminate the portion of the bottom which is photographed.

The space between plate 50 and the inside surface of hemisphere 48 is filled with a transparent fluid 53′ to

provide a "fluid lens" 54'. The fluid lens provides a unique way to eliminate the distorting effect of imperfections in the inner surface of the hemisphere and also avoids distortion of a picture taken by the camera due to the curvature of the hemisphere. The refractive index of fluid 53' is so chosen as to eliminate, so far as is possible, the adverse effects of differences between the refractive index of the hemisphere material and the refractive index of sea water. It has been found that water works quite well as fluid 53' and matches the refractive indices mentioned above sufficiently well that no extensive distortion of a photograph taken at the bottom occurs. The fluid lens 54' has two significant functions, first, it eliminates the effect of imperfections of the inner surface of the hemisphere on light travelling from the inside to the outside of the hemisphere, and second, it eliminates considerably distortions due to the curvature of the hemisphere.

Where complete elimination of distortion is required, a ring 55' of a diameter essentially the same as the diameter of plate 50 is cemented to the outside of hemisphere 47 with its axis aligned with the center of plate 50. Fitted into ring 55' is an outer plate 57' which is spaced slightly from the outside surface of hemisphere 47. Thus, there is a second space between the outside surface of the hemisphere and outer plate 57'. Where the ring and outer plate are used, both the space between plate 50 and the inside of the hemisphere, and plate 57' and the outside of the hemisphere are filled with a transparent fluid 53' of the same index of refraction as the hemisphere material. When the spaces are so filled with material of the same refractive index, the hemisphere material is eliminated optically from the fluid lens. Thus, no distortion at all occurs because the camera lens is parallel to both plates 50 and 57' and thus, the distorting effects of refraction are completely eliminated by the fluid lens 54'. Advantageously, no high pressure seals are required since the lens does not have parts that extend through the hemisphere 47. In addition, since the space within ring 55' is filled with a liquid (which is incompressible), high external pressures will not damage the liquid lens.

Strut 51 is advantageously painted completely black. The absorbtive effect of a black color on light substantially eliminates reverberation of light through the fluid 53' from flash unit 56 to the lens of camera 54, when the flash unit is fired.

The shutter of camera 54 is actuated in a unique manner. As shown in FIGS. 4 and 12, a solenoid 57 is connected in series circuit relation with a switch 58 and a battery 59, all contained within sphere 9. Solenoid 57 has a plunger 60 connected to the shutter of the camera to operate the shutter when solenoid 57 is energized. Switch 58 is a magnetically actuable glass enclosed reed switch, of the normally open type, having a movable magnetic contact 61 and a stationary contact 62. Switch 58 is mounted on the inside surface of hemisphere 47. Engaging hemisphere 48 on the outside immediately opposite switch 58 is an actuator tube 63 formed of nonmagnetic material such as stainless steel, which is readily weldable and has an open top end and a bottom end with a small, centrally located opening therein. Located within tube 63 is a cylindrical magnet 64 and a spring 65 disposed between the magnet and the lower end of tube 63. A string 66 is connected to the bottom of the magnet and extends through the opening in the bottom of the tube. String 66 is maintained taut (before the jaws are released) to hold magnet 64 in a lowered position within tube 63, and spring 65 is under compression. Since magnet 64, in this position, is substantially below switch 58, the switch contacts remain open. However, when the string 66 is released, spring 65 forces the magnet upwardly and switch contacts 61 and 62 close as magnet 64 passes by switch 58. With string 66 released, magnet 64 ultimately assumes an upper position above switch 58 and adjacent switch 58', the switch 58' controlling a radio or a flasher (not shown) inside the hemisphere to facilitate recovery, as will be explained later.

Jaw 5 is fabricated from a pair of parallel side plates 67 and 68 spaced apart a distance slightly greater than the distance between the outside surfaces of side plates 15 and 16 of base 3. Side plates 67 and 68 are each formed from heavy guage sheet metal and have rear edges 69 and 70 respectively, which form the rear face of jaw 5. Side plates 67 and 68 also have front edges 71 which form a front face of jaw 5, the front edges being sharpened along a substantial portion of their length to form a knife edge 72 which assists cutting or slicing a sample when the jaws close. Side plates 67 and 68 each have a first side edge 73 which extends at an acute angle to front edge 71 and merges with both the front edge and the rear edge of the respective plates at smoothly rounded corners 74 and 75. At the opposite ends of side plates 67 and 68 is a side edge 76 which extends generally perpendicularly to front edge 71. Adjacent corners 75 of side plates 67 and 68 is a tubular cross-member 77 which is welded to the inwardly facing surfaces of the side plates. Bolts 78 and 79 which pass through openings in the side plates adjacent corners 74,75 pivotally mount jaw 5 on the base. A toothed cutter 80 extends between side plates 67 and 68; is secured to the side plates and lies against side edge 76, cutter blade 80 is so mounted on the side plates that it is tangent to a circle about the pivotal axis of the jaw.

Rear edges 69 and 70 of side plates 67 and 68 each slope first downwardly toward front edges 71 of the plates and then curve arcuately upwardly before merging with side edge 76 to form upwardly facing arcuate cradles 82 and 83 in the respective side plates.

As shown at FIG. 1, weight 12 has a cylindrical body 84 with enlarged cylindrical ends 85 and 86. Body 84 is slightly longer than the distance between plates 67 and 68 and thus, the inwardly facing transverse surfaces 87' of ends 85 and 86 extend beside the outer surfaces of side plates 67 and 68.

Jaw 6 is identical to jaw 5 and in the position shown at FIG. 1, jaw 6 is merely jaw 5 rotated 180° in a horizontal plane. Thus, jaw 6 includes spaced apart side plates 87 and 88, a cross-member 89 extending between secured side plates, and a sample slicing or cutting blade 90 secured to and extending between the side plates. The side plates 87 and 88 have front edges 91 with sharpened knife edges 92, and rear edges 93 each having a weight receiving cradle 94 which faces upwardly when the jaws are in the open position of FIG. 1. Jaw 6 is pivotally mounted on base 3 with bolts 94'. Weight 13 is identical to weight 12 and has a body 95 with enlarged ends 96 and 97. Ends 96 and 97 extend on each side of side plates 87 and 88 in the same manner as described for weight 12, when weight 13 is placed in cradles 94.

As shown in FIG. 1, jaws 5 and 6 have both an open front and an open back. The open back of jaw 6 is closed by a sample retaining sack or bag 98 which extends across the side plates and is secured to them at the rear edges 93. Sack 98 also extends to and is secured to rear edge 99 of cutter blade 90. A series of spaced apart openings formed adjacent the rear edges of the side plates and cutter blade 90 provide for sewing or tying the sack to the jaw with cord 100 by threading the cord through the openings. Sack 98 is formed from a flexible imperforate web or can also be net or other mesh material sewn and dimensioned to bulge outwardly when the jaws are closed, as shown at FIG. 6. Advantageously, sack 98 is formed from a flexible non-elastic material such as canvas or fine mesh fish net. An identical sack 101 extends across the rear face of jaw 5 and is similarly secured to the jaw.

FIGS. 5 and 6 show jaws 5' and 6' in modified form as well as base 3' in modified form. Here, side plates 15' have bottom edges 17' and 18' which slope downwardly to meet at an apex 19'. Jaw 5', while essentially the same as jaw 5, shown at FIG. 1, has a side plate 67' with a front edge 71' comprised of edges 72' and 73' which slope toward each other and meet at a point 74'. In addition, edge 72' extends to the front edge of cutter blade 80, edge 72' being sharpened to facilitate slicing a sample when the jaws are closed. Jaw 6' is identical to jaw 5' and includes a modified side plate 87' with a bottom edge 88' comprised of edges 89' and 90' which extend at an angle to each other and meet at a point 91'. Edge 90' extends to the front edge of cutter blade 90. Except for these modifications of jaws 5', 6', and base 15', the sampler of FIGS. 5 and 6 is identical to that of FIG. 1.

The jaws are moved from the open position of FIGS. 1 and 5 to the closed position of FIG. 6 by resilient elements 7. As shown in FIG. 1, there are three resilient elements which take the form of lengths of surgical tubing with their ends interconnected by separable fasteners 102 to form closed bands 103–105. As shown with reference to band 105, each band has an end 106 which is looped over cross tube 77 and extends downwardly under cross tube 18, a second end 107 which is looped over cross tube 89 and extends downwardly across tube 19 and legs 108 and 109, which extend respectively between cross tubes 18 and 19, with leg 109 extending over cross tube 17. Since the pivotal connections for jaws 5 and 6 as provided respectively by bolts 78, 79 and 94' are inwardly of cross tubes 18 and 19 around which the bands 103–105 extend, a substantial lever arm is provided to assure good closing of the jaws, when released.

Jaws 5 and 6 are held in the open position against the biasing action of resilient element 7 by jaw actuating mechanism 8 located vertically above the horizontal center of these three.

The jaw actuating mechanism includes a horizontal connector 111 (FIG. 2) to which arms 112 and 113 are connected adjacent their upper ends for pivotal movement about horizontal axis by pins 114 and 115. As shown at FIG. 3, connector 111 is H-shaped as viewed in plan and arms 112 and 113 extend into the vertical slots of the connector. Arm 112 has a notch 116 adjacent its upper end, the notch being defined in part by an inwardly extending cable retaining finger 117. Similarly, arm 113 has a downwardly facing notch 118 which is defined in part by an inwardly extending cable retaining finger 119. Arm 112 has an elongated downwardly extending tapered leg 120 and arm 113 has an elongated downwardly extending tapered leg 121. The lower ends of legs 120 and 121 extend into an upwardly facing recess 122 of a retaining cup 123. An elongated rod 124 is fixed to the center of the cup and extends upwardly through an opening centrally located in connector 111, the rod having its upper end threaded to permit threading the rod into a nut 125 imbedded in the bottom of a suction cup 126. As shown at FIGS. 1 and 2, suction cup 126 is adhered to the bottom of sphere 11 with its center along the vertical axis of the sphere.

Fixed to the center of cross-tube 77 of jaw 5 is a retaining cable 127 having a loop 128 at its inner end. A cable 129 is fixed to the center of cross-tube 89 of jaw 6 and also has a loop 130 at its inner end. Cables 127 and 129 hold jaws 5 and 6 in the open position with loop 128 extending into notch 116 and loop 130 extending into notch 118. The inwardly extending portions of fingers 117 and 119 prevent the cables from slipping downwardly off the fingers, so long as arms 120 and 121 are held by cup 123. The resilient elements 7 which normally tend to close jaws 5 and 6, maintain cables 127 and 129 taut and in position in the notches. It will be noted, with reference to FIG. 2, that the line of action of cables 127 and 129 is slightly below the axis of pivot pins 114 and 115 and thus, if retaining cup 123 is moved downwardly, legs 120 and 121 will each pivot outwardly away from rod 124, the cables will be released, and the jaws will close under the action of resilient elements 7.

As shown at FIG. 1, sphere 10 is connected to sphere 11 by a double ended suction cup which lies along the vertical axes of the spheres. Spheres 10 and 11 are each formed from glass or plastic and are hollow but have considerable mass. Thus, when the sampler 1 is in the water, with the jaws open, spheres 10 and 11 exert an upward pull of the cup to retain the lower ends of legs 120 and 121 in recess 122 of the cup. The sampler descends quite rapidly through the water because of ballast weights 12 and 13 and when base 3 of the sampler strikes the bottom, spheres 10 and 11 momentarily continue to move downwardly because of their inertia, as shown at FIG. 5. Retaining cup 123 is thus pushed downwardly relative to the arms (downward movement of the arms being prevented by the cables) so the legs are released and arms are free to pivot outwardly thereby releasing the cables and allowing jaws 5 and 6 to close.

As shown at FIGS. 1 and 8, flare and signal assembly 14 is secured to the upper end of upright tube 24. The upper end of flare assembly 14 extends above the upper end of sphere 9. As shown at FIG. 8, the lower end 140 of flare assembly 14 has a diameter slightly less than the inside diameter of the tube 24 and has self cutting threads 141 to permit threading the flare assembly into the tube. End 140 merges with a cylindrical body 142 at a shoulder 143 which acts as a stop to limit the amount the flare can be threaded into tube 24. Body 142 is cylindrical and has a reduced diameter portion 144 that merges with body 142 at transverse upwardly facing shoulder 145 which provides a seat for the lower end of a closure sleeve 146. Projecting from the upper end of portion 144 is an integral tube 147 which is internally threaded to receive the threaded tip of a primer assembly 148 of a flare and smoke cartridge 149.

The upper end of sleeve **146** is closed by a bushing **150** having a plug portion **151** that extends into the sleeve. A transverse shoulder **152** of the bushing abuts the end of the sleeve. The bushing is permanently and hermetically fixed to the sleeve by an epoxy cement **152'** solidified in opposed annular grooves around the bushing and the upper end of the sleeve, as shown at FIG. **8.** Bushing **150** has a central opening **153** that is closed by a plug **154** which is friction fit in the opening. A retaining string or wire **154'** is connected between plug **154** and bushing **150** to retain the plug against loss when the flare is fired. Suitable O-ring seals are provided between the head of plug **154** and the top fact of bushing **150** as well as around the stem of plug **154** to prevent leakage of water through bore **153.** A suitable O-ring is also provided between body **142** and the lower end of sleeve **146** to prevent leakage of water into the flare assembly at the joint between the body **142** and the sleeve.

Body **142** has a bore **155** which terminates a short distance from the bottom of lower end **140.** A firing pin **156** is slideable in bore **155** and a helically wound spring **157** extends between the bottom of firing pin **156** and the lower end of bore **155.** Firing pin **156** has an upwardly facing tapered shoulder **158** and a rounded tip **159** projecting upwardly up from the shoulder.

A transverse bore **160** is formed in body **142** and has its axis tangent to the circumferential surface of bore **155.** A sear pin **161** extends into and is journalled for rotation in bore **160.** Sear pin **161** has a flat **162** formed therein, as by milling, the flat being aligned with a surface of bore **155.** Opposite flat **162** is a rounded portion **163** of the sear pin which, in the position shown, extends radially into bore **155** and engages shoulder **158** of firing pin **156** to maintain the pin in a depressed or loaded position in which spring **157** is compressed.

Sear pin **161** has an enlarged head **164** by which the sear pin is connected to an operating assembly **165.** Operating assembly **165** includes a straight arm **166** to which head **164** is connected intermediate the ends of the arm. Fixed to the lower end of arm **166** is a flexible vane **167** which extends upwardly and curves outwardly away from the arm. A float **168** is secured to the upper end of arm **166** and extends beside sleeve **146** when operating assembly **165** is in the position of FIGS. **7–10** in which the firing pin is cocked. It will be noted that arm **166** is connected to float **168** at a position offset to one side of the center of the float. Connected to and extending downwardly from the opposite side of float **168** is a vane **169,** vane **169** curving outwardly. A stop pin **170** is secured to float **168** and prevents counter-clockwise movement of operating assembly **165** (as shown at FIG. **9**) relative to flare **14** by engagement of the pin with sleeve **146** of the flare.

Cartridge **149** includes an elongated cylinder of smoke-producing compound **171** which extends upwardly within sleeve **146** from primer **148** to bushing **150.** Smoke-producing compound **171** has a central opening the upper end of which is closed by a flare cartridge **172.** Thus, when firing pin **156** is released it strikes primer **173** at the base of primer tube **148** and ignites the primer, which in turn ignites smoke producing compound **171** and flare cartridge **172.**

Operating assembly **165** prevents rotation of sear pin **161** to the position in which firing pin **156** is released, until the sampler has surfaced. As shown at FIG. **9,** during descent of the sampler the water through which the sampler passes exerts a force, as shown by the arrows **174,** on the underside of vane **169** thereby bowing the vane outwardly and exerting a counter-clockwise moment of force on operating assembly **165.** This counter-clockwise moment of force merely urges pin **170** against the side of sleeve **146** and thus, float **168** remains upright and the operating assembly does not rotate. During descent, vane **167** is pressed inwardly toward arm **166** by the water through which the sampler passes and thus, vane **167** creates only a minimal clockwise moment of force on operating assembly **165.** Thus, operating assembly **165** prevents firing flare **14** while the sampler is descending.

A shallow water seal arrangement is provided between bore **160** and shear pin **161.** This seal arrangement includes an annular groove **173'** in which an O-ring **174'** is seated. At shallow depths, O-ring **173'** prevents leakage of water between shear pin **161** and bore **160.**

In addition, a high pressure seal arrangement is also provided. With reference to FIG. **7** a seal ring **175** is disposed between the inside surface of head **164** of sear pin **161** and the outer surface of body **142** of the lower end of the flare. In addition, it will be noted that sear pin **161** is slightly shorter than bore **160** so that the sear pin can move axially in the bore. Since the area within seal ring **175** is substantially less than the area of head **164** exposed to water pressure, the pressure of the water exerts a substantial force tending to push sear pin **161** further into bore **160** when the sampler reaches a substantial depth in the water. As a result of the pressure and movement of the sear pin, seal **175** is forced tightly against the surface of body **142** to provide a high pressure seal and there is sufficient friction between seal **175** and body **142** to prevent rotation of the sear pin **161** or operating assembly **165** after the sampler reaches a substantial depth.

After a sample is taken and the sampler ascends, as shown at FIG. **10,** the water pressure gradually decreases as the sampler approaches the surface and the friction between seal **175** and body **142** is no longer sufficient to prevent rotation of operating assembly **165.** However, as the sampler ascends vane **167** is bowed outwardly by the water as shown by arrows **176,** FIG. **10,** whereas vane **169** is collapsed against the side of float **168.** Thus, a counter-clockwise moment of force again acts on operating assembly **165** and float **168** remains upright because of engagement of pin **170** with the side of the flare.

When the sampler surfaces flare **14** extends above the surface of the water. Thus, there are no external forces acting on operating assembly **165.** However, since float **168** is mounted at a position offset to one side of arm **166,** the float exerts a clockwise moment of force which causes operating assembly **165** to begin rotating in a clockwise direction as shown at FIG. **11.** As soon as flat **162** of sear pin **161** begins to engage shoulder **158** of firing pin **156,** a torque is exerted on the sear pin by the firing pin and correspondingly the operating assembly is rapidly rotated to the position of FIG. **11** in which firing pin **158** is free to strike primer **173.** When flat **162** is aligned with the side of bore **155,** firing pin **156** is released to strike the primer and ignite smoke cartridge **171** and flare **172.** As flare **172** is projected from the flare assembly it provides an illuminated signal to personnel on the ship from which the

sampler was dropped. In addition, smoke producing compound **171** produces smoke for a considerable length of time after the flare is fixed.

Flare assembly **14**, in some instances, is quite desirable as where a number of samplers are dropped in the same area and where ocean currents do not cause considerable drift of the samplers. However, a radio homing device can also be used to advantage. Such a homing device may take the form of a small transistor located within sphere **9**, the transmitter being arranged to either provide a signal from the time the sampler is dropped, or to be set into operation when camera **54** is triggered or as magnet **64** reaches a position opposite switch **58'**. Where such a radio transmitter is used direction finding equipment is provided on the mother ship from which the sampler is dropped, and since several ships are frequently used to obtain representative samples of a certain area of the ocean floor, a second direction finder on another ship facilitates locating the surfaced sampler.

The homing device of course can take the form of a radio transmitter in a sealed package mounted on the frame of the sampler. For nighttime recovery of the sampler after it has surfaced, a flashing light may be located either inside sphere **9** and arranged to operate in the same manner described for the radio homing device, or can be located in a pressure type case and mounted on one of legs **24–27**.

To facilitate retrieving the sampler after it has returned to the surface of the body of water in which it is dropped, a retrieving line **180'** is advantageously provided between the ends of legs **25** and **27**, as shown at FIG. **1**. This retrieving line facilitates catching the sampler with a boat hook.

OPERATION AND USE

Prior to dropping the sampler into the water where the bottom is to be sampled, camera **54** is loaded and positioned in lower hemisphere **48**. The lower hemisphere is then positioned in clamp ring **30**, upper hemisphere **47** is placed on the lower hemisphere, the clamp assembly **36** is fitted on the clamp ring, and clamp bolt **44** is tightened to seal upper hemisphere **47** to lower hemisphere **48**.

Next, jaws **5** and **6** are moved to the open position of FIG. **1** using a suitable jaw-loading tool to open the jaws against the bias of resilient element **7**, and the jaws are latched in position by connecting cables **127** and **129** to jaw actuating mechanism **8**. Since the weight of spheres **10** and **11** tends to normally release jaw actuating mechanism **8** when the sampler is out of the water, the jaw actuating mechanism is temporarily locked in the latched position of FIG. **2** with rubber bands that extend under cup **123**, and are cut after the sampler is lowered into the water but before it is released.

Weights **12** and **13** are placed in the cradles of the respective jaws and sampler **1** is then ready to be used.

In use the sampler is merely lowered into the water at the desired location where a sample of the bottom is to be taken, in the upright position of FIG. **1**, and is then released. With weights **12** and **13** in position, the sampler has a negative buoyancy sufficient to cause the sampler to sink at a rate of 100 ft./min. to 300 ft./min., depending of course on the density of the water in which the sampler is dropped, and the mass of the weights. As soon as spheres **10** and **11** are in the water, an upward pull is exerted on rod **124** and cup **123** remains engaged with the arms **112** and **113** of the operating assembly. Thus, the jaws are held in the open position after the rubber bands are cut and throughout descent of the sampler.

As shown at FIG. **5**, the instant sampler **1** hits bottom **177** of the body of water in which the sampler is dropped, the inertia of spheres **10** and **11** causes the spheres to continue to move downwardly. Such downward movement of spheres **10** and **11** pushes cup **123** downwardly which releases arms **112** and **113** allowing cables **127** and **129** to release, thereby freeing jaws **5** and **6** to close under the influence of resilient elements **7**.

As shown at FIG. **1**, string **66** is connected to cross member **89** of jaw **6**. When the connection is made between the string and the jaw, the string is made taut so magnet **64** is pulled to the position of FIG. **4** wherein the magnet is below reed switch **58** and spring **65** is compressed. The string is preferably made of a thin thread which readily breaks as jaws **5** and **6** close. As soon as the string **66** breaks, the magnet is free to move upwardly under the influence of spring **65**. When magnet **64** is immediately opposite reed switch **58**, contacts **61** and **62** are magnetically attracted to each other, causing the contacts to close whereupon shutter **55** is operated by solenoid **57** and flashbulb **56** is simultaneously actuated to obtain a photograph of the bottom of the body of water from which the sample is taken. Continued upward movement of the magnet actuates switch **58'**, as previously explained to actuate the auxiliary signal devices.

It will be observed with reference to FIG. **1**, that front edges **71** and **91** of the respective jaws extend at an acute angle to the surface of bottom **177** upon initial impact of the sampler with the bottom. As soon as jaw actuating mechanism **8** is released, the resilient elements initiate closing of the jaws, and weights **12** and **13** exert downwardly acting forces which assist the initial closing of the jaws into bottom **177**. As the jaws dig into the bottom, sacks **98** and **101** begin to fill and are forced outwardly beyond the rear faces of the jaws thereby unseating weights **12** and **13** which merely roll out of the cradles in the respective jaws. As soon as weights **12** and **13** are displaced from the jaws, the buoyant force of spheres **9-11** tends to lift the sampler. Thus, as jaws **5** and **6** close under the forces from resilient elements **7**, a substantial pull is applied to the sampler which pulls the sample between the jaws free from the bottom and then returns the sampler to the surface. Cutters **80** and **90** engage each other when the jaws are closed, and front edges **71** and **91** oppose each other. When sampler **1** reaches the surface, flare **14** fires in the manner previously described to indicate that the sampler is surfaced. The sampler is then recovered and the bottom sample in the jaws can be examined.

With reference to the modified embodiment of the sampler shown at FIGS. **5** and **6**, when the sampler engages the bottom, the points **74'** and **91'** of the jaws **5'** and **6'** sink slightly into bottom **177** as does point **19'** of base plate **15'**. In addition, the sloping edges **87'** and **91'** of jaw **6'** and the slopong edges **72'** and **73'** of jaw **5'** cooperate with the sloping edges **17'** and **19'** of the base to provide an inherently stable base which virtually eliminates any possibility of tipping of the sampler even where bottom **177** slopes substantially. As shown at FIG. **6**, when jaws **5'** and **6'** close edges **72'** and **89'** are in abutting relationship to each other and corre-

spondingly oppose each other in addition, the cutters **80** and **90** engage each other so that a substantial area within the jaws is closed against lost of the sample taken when the jaws close. As jaws **5'** and **6'** were moving to the position of FIG. **6** the portion of bottom **177** sliced by the jaws cause bulging of bags **98** and **101** with the result that weights **12** and **13** were forced out of the cradles and rolled to one side of the opening **178** formed by the jaws.

To rouse the sampler, it is merely necessary to provide new weights **12** and **13,** reload camera **54,** and provide a new flare assembly **14.** Then, the jaws are reopened, held in position by operating assembly **8** as previously described, and the sampler is again dropped into the water where it performs the same bottom sampling operation just described.

While a preferred embodiment of the sampler of this invention has been shown and described, it is to be understood that numerous changes and modifications are contemplated. For example, while the backs of the jaws are shown closed with a flexible member or web which may be either imperforate or of meshed material, a sheet metal plate suitably formed to permit accommodating the weights **12** and **13** in their respective cradles may also be used to close the backs of the jaws. In addition, it is contemplated that flotation devices other than hollow spheres **10** and **11** for example, solid spheres or blocks can be used to provide buoyancy for the sampler. In addition, plastics impregnated with gases or having air cells therein may be used to provide the desired buoyancy. Also, suitable bracing can be provided within hollow spheres **10** and **11** or these spheres can be filled with a low density liquid to prevent implosion.

Thus, while some of the contemplated changes that can be made in the preferred embodiment without departing from the scope of the invention as herein contemplated have been listed above, it is intended that the scope of the invention shall be as defined herein and in the appended claims.

What is claimed is:

1. A free fall recoverable device for obtaining a picture of the bottom of a body of water comprising, in combination

a frame;

buoyant means carried by said frame;

releasable ballast means carried by said frame;

said device, with said ballast means, exhibiting negative buoyancy, whereby said device will sink to the bottom of the body of water when released from the surface;

said device, without ballast means, exhibiting positive buoyance, whereby said device will return to the surface of the body of water when the ballast means is released;

a sealed housing carried by said frame, said housing having

a transparent wall portion, and

a wall portion of non-magnetic material;

a camera within said housing and positioned to obtain a picture through said transparent wall portion;

camera operating means within said housing and including a magnetically responsive actuating element adjacent the inside of said wall portion of non-magnetic material;

means outside said housing to operate said actuating element, said means comprising

a magnet at the outside of said wall portion of non-magnetic material and positioned adjacent said actuating element;

magnet operating means responsive to impact of said re-coverable device with the bottom of the body of water to cause said magnet to operate said actuating element; and

means for releasing said ballast means in response to impact of the recoverable device with the bottom of the body of water;

whereby, the device returns to the surface of the body of water by virtue of its positive bouyancy after a picture is taken and the ballast means is released.

2. A device according to claim **1** wherein

said sealed housing is fixed to said frame, and said camera is fixed in said housing;

a flash unit is secured in said housing; and

said camera operating means operates said flash unit in synchronism with the camera.

3. A device according to claim **2** wherein

said magnetically responsive actuating element is a magnetically operable switch;

said camera operating means includes

said magnetically operable switch,

a solenoid operably associated with said camera and electrically connected to said switch, and

electrical energy storing means to operate said solenoid in response to operation of said switch.

4. A device according to claim **3** wherein

said magnet is a permanent magnet;

said switch is normally open; and

said magnet operating means, in response to impact of said recoverable device with the bottom of the body of water, moves said magnet to a position to close said normally open switch.

5. A device according to claim **4** wherein

said electrical energy storing means is a battery.

6. A device according to claim **1** wherein

said magnet is a permanent magnet;

guide means are carried by said frame at a location adjacent said wall portion of non-magnetic material to guide said magnet along a predetermined path; and

said magnet operating means, responsive to impact of the device with the bottom of the body of water, moves said magnet along said guide means.

7. A device according to claim **1** wherein

said frame is vertically elongated;

said buoyant means carried by said frame includes a hollow sphere adjacent the upper end of the frame; and

said releasable ballast means includes a weight adjacent the lower end of the frame.

8. A free fall recoverable device for obtaining a picture of the bottom of a body of water at substantial underwater depths comprising, in combination

a frame;

means defining a sealed high pressure resistant housing carried by said frame, said housing having a transparent wall portion;

a camera within said housing, said camera having a shutter, and a lens within the housing;

means for mounting the camera in the housing to take an underwater photograph through said transparent wall portion;

circuit means within said housing to operate the shutter of said camera, said circuit means including switch means within said housing

said switch being operable to a first condition in which the circuit means is in an energized condition and the shutter is operated, and

a second condition in which the circuit means is in an unenergized condition;

switch operating means outside said housing and completely isolated from said circuit means, both electrically and mechanically to operate said switch means to said first position in response to engagement of said recoverable device with the bottom of the body of water;

said switch operating means including

a switch operating element adjacent the outside of the housing and moveable along a predetermined path in response to engage-ment of the recoverable device with the bottom of the body of water;

said switch means including

means mounted on the inside of the housing along the path of travel of the switch operating element and responsive to a physical characteristic of the switch operating element so that movement of the switch operating element along its path operates the switch means from one of its conditions to the other; whereby, said recoverable device is particularly characterized by the absence of mechanical and electrical connections from the outside of the housing to the inside of the housing, to operate the shutter of the camera.

9. A device according to claim **8** wherein

said operating means includes

resilient means, and

means normally restraining said resilient means and releasable in response to engagement of the device with the bottom of the body of water.

10. A device according to claim **9** wherein said resilient means includes at least one elastic band.

11. An underwater camera arrangement for obtaining an undistorted underwater picture and capable of use in deep water at substantial pressures comprising, in combination,

a sealed housing having a curved transparent wall and resistant to substantial external pressure;

a chamber inside the housing and defined in part by an inside surface of the curved wall, the chamber comprising

a flat transparent plate extending across an inside surface of the curved wall,

means securing the plate to the inside surface of the curved wall in sealed relation to the wall, and

a transparent liquid within the chamber and contacting substantial portions of the surfaces of the curved wall and plate defining the chamber, the liquid having an index of refraction approximately the same as the index of refraction of water;

a camera within the enclosure and outside the chamber defined by the flat plate and curved wall;

means mounting the camera with its lens axis generally perpendicular to the flat wall to obtain a photograph through the flat wall, transparent liquid, and curved wall;

whereby a photograph taken by the camera when the housing is underwater, is essentially undistorted.

12. An underwater camera arrangement according to claim **11** wherein

a light source is positioned within the enclosure in spaced relation to the camera lens to illuminate the region to be photographed by the camera;

light emitted by the light source passes through a region of the plate, transparent liquid, and curved wall which is spaced from the lens axis; and

an optically black strut extends between the transparent plate and the curved wall to isolate the portion of the chamber through which light from the source passes from the portion of the chamber through which the lens axis of the camera passes.

13. A free fall recoverable device for obtaining a picture of the bottom of a body of water comprising, in combination

a frame;

buoyant means carried by said frame;

releasable ballast means carried by said frame;

said device, with said ballast means, exhibiting negative buoyancy, whereby said device will return to the surface of the body of water after release of the ballast means;

a sealed housing carried by said frame, said housing having

a transparent wall portion, and

a wall portion of non-magnetic material;

a camera within said housing and positioned to obtain a picture through said transparent wall portion;

camera operating means within said housing and including a magnetically responsive actuating element adjacent the inside of said wall portion of non-magnetic material;

means outside said housing to operate said actuating element, said means comprising

a permanent magnet at the outside of said wall portion of non-magnetic material and positioned adjacent said actuating element, and

guide means carried by the frame at a location adjacent the non-magnetic material wall portion to guide the magnet along a predetermined path;

magnet operating means responsive to impact of said recoverable device with the bottom of the body of water to move said magnet along the guide means to operate said actuating element, said magnet operating means including

resilient means urging the magnet operating means toward a position in which said magnet is operated, and

latch means responsive to impact with the bottom of the body of water to release said operating means.

14. A free fall recoverable device according to claim **1** wherein

said means for releasing the ballast means and said magnet operating means include a common latch responsive to impact of the free fall device with the bottom of the body of water to actuate both said means.

15. An underwater camera arrangement for obtaining an undistorted underwater picture and capable of use in deep water at substantial pressures comprising, in combination,

a sealed housing having a curved transparent wall and resistant to substantial external pressure;

a chamber inside the housing and defined in part by an inside surface of the curved wall, the chamber comprising

a flat transparent plate extending across an inside surface of the curved wall,

means securing the plate to the inside surface of the curved wall in sealed relation to the wall, and

a transparent liquid within the chamber and contacting substantial portions of the surfaces of the curved wall and plate defining the chamber, the liquid having an index of refraction approximating the index of refraction of the curved portion of the transparent wall;

a camera within the enclosure and outside the chamber defined by the flat plate and curved wall;

means mounting the camera with its lens axis generally perpendicular to the flat wall to obtain a photograph through the flat wall, transparent liquid, and curved wall;

a second chamber is defined in part by an outside surface of the curved wall of the housing, the second chamber comprising

a second flat transparent plate extending across an outside surface of the curved wall in parallel opposed relation to the first mentioned flat plate,

means securing the second plate to the outside of the curved wall to define the second sealed chamber, and

a transparent liquid within the second chamber and completely filling the second chamber, the transparent liquid having an index of refraction approximating the index of refraction of the material of the curved transparent wall;

whereby a photograph taken by the camera, when the housing is underwater, is essentially undistorted.

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