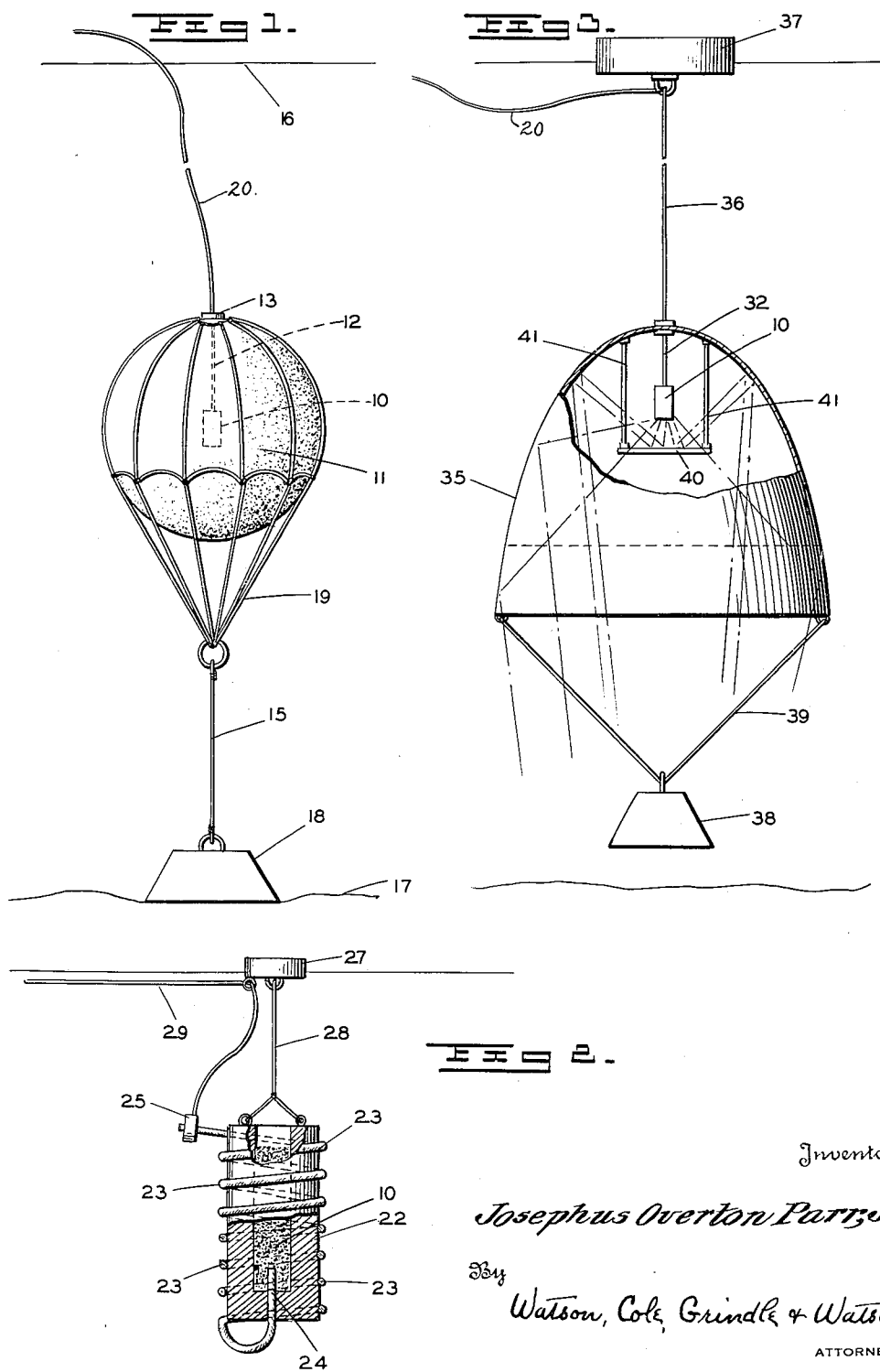


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SEISMIC SURVEYING
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SEISMIC SURVEYING

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This invention relates to an improved method of propagating seismic waves in underwater formations and to apparatus suitable for use in the practice of the method. More particularly, it is an object of the invention to provide an improved method and apparatus for detonating a charge of explosive in water in geophysical prospecting of underwater strata by means of which a number of difficulties commonly encountered in present practice can be minimized or avoided, and which will permit the detonation of explosives at depths greater than those now commonly regarded as the optimum, with resultant increase in the efficiency of the explosive.

It is well known that the damage to marine life resulting from the firing of explosives under water is caused principally by transmission through the water of high velocity energy waves of supersonic frequency, whereas useful seismic wave energy within the sound range is not injurious to most living organisms. I have discovered that the magnitude of supersonic energy released by an explosion beneath water may be greatly reduced if the explosive charge is detonated in a gaseous medium by which the charge is isolated from direct contact with the water, for instance by the provision of a gaseous pocket in which the charge is suspended and within which the initial expansion can occur. Presumably the explosive shock is cushioned by the gaseous medium and the initial impact correspondingly reduced. Whatever the cause, it can be shown that a charge so exploded dissipates much less energy in the form of waves having a velocity of the order of 5,000 feet or more per second, and causes no substantial damage to marine life.

I have also found that when a charge is detonated under water and in a surrounding gaseous pocket, the bubble effect noted by Lay et al. in U. S. Patent 2,351,524, granted June 13, 1944, is practically eliminated even though the charge is exploded at such a depth that "blow-out" of the water above the explosion cannot occur. Consequently I am enabled by the practice of the present invention to improve the efficiency of the explosive in generating seismic waves in the underlying strata without giving rise to secondary P waves of undesirable magnitude.

In the preferred method of practicing the invention, the gaseous pocket may be provided by suspending the explosive charge within an enclosure, for instance a balloon or a bell, which is positioned at the desired depth in the water in any conventional manner before firing. Alternatively, a gaseous pocket may be created around the explosive by first detonating a relatively small gas releasing charge, whereby the gaseous pocket is formed in situ immediately before the firing of the charge which propagates the seismic waves.

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Further objects and features of the invention will be apparent from the following description taken in connection with the accompanying drawings, in which:

Figure 1 illustrates one form of equipment satisfactory for the practice of the invention, in which the gaseous medium is confined within an enclosure;

Figure 2 illustrates an alternative method wherein the surrounding gas pocket is formed by the detonation of a gas-producing charge prior to the firing of the main explosive; and

Figure 3 represents a modification of Figure 1 in which the charge is suspended in the air trapped within a bell having an open bottom.

In order to facilitate an understanding of the invention, reference is made herein to specific methods and apparatus, but it will be understood that no limitation of the scope of the invention is thereby intended, various further methods and alterations, such as would occur to those skilled in the art, being contemplated herein.

Referring first to Figure 1, it will be observed that the charge of explosive 10 is suspended in an enclosure constituted by a balloon 11, the supporting line 12 therefor being secured to the upper side of the balloon at 13. A weight 18 may be secured to the balloon, for instance by snood 19 or the like, to carry the balloon down, a line 15 of selected length serving to position the balloon at the desired depth when the weight 18 rests on the bottom. The balloon may be filled with air or any other suitable gaseous medium, the latter term being employed herein to include air. Suitable electrical connections, such as the usual shot line 20, may extend through line 12 to a detonating cap or the like associated with the explosive charge 10. It will be appreciated that the balloon and charge may be suspended from the surface of the water in the conventional manner by a line of selected length depending from a float, as shown in other figures of the drawing.

By employing an enclosure of adequate size, the high velocity waves commonly dissipated through water by the firing of an explosive therein are suppressed sufficiently to eliminate damage to fish and other living organisms, and disturbing effects of secondary P waves are minimized, so that the formula prescribed in the patent to Lay et al. above mentioned need not be observed.

In Figure 2 is shown a modification whereby the gaseous pocket is created immediately prior to the detonation of the main charge. This may be achieved by positioning the charge 10 within a sleeve or container 22, which may be formed of wood or water-resistant fibrous material. A gas releasing charge, for instance a detonating fuse 23 of the type known as primacord, is wrapped around the sleeve 22, the latter serving to space the fuse from the main charge 10. One end of the fuse extends into the main charge 10 at 24 to det-

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onate the latter, a blasting cap 25 being associated with the other end of the fuse. The assembly is supported from the surface of the water by a float 27 and a depending line 28 of selected length, and the cap 25 is detonated by a shotline 29 or other electrical connections.

It will be appreciated that on detonation, the fuse 23 first evolves a gas which forms a gaseous pocket around the assembly. Immediately thereafter the main charge 10 is detonated, so that firing occurs within a gaseous pocket as in the form of the invention illustrated in Figure 1.

Figure 3 shows a further variation in which the charge 10 is suspended by a line 32 in a bell or similar enclosure 35 which is open at the bottom, the length of line 32 being such that the explosive is positioned above the level of water rising in the bell as the latter is lowered. The bell is carried on a line 36 depending from a float 37, the length of line 36 being such that the desired depth is reached. Detonation is effected by a shot line 20, which may be carried down to the charge 10 through line 36. In order to ensure that the bell will remain in the proper position when lowered, a weight 38 may be secured by lines 39 to the open mouth thereof.

The bell 35 may be fairly heavy, for instance being formed of metal, and may have a substantially parabolic shape, so that when the charge is positioned substantially at the parabolic focus, the energy released by the explosion will be reflected downwardly in parallel or converging waves, whereby the force of the explosion is concentrated and the efficiency of the explosive correspondingly increased. The effect may be heightened by the use of a baffle plate 40, which may be circular in plan, suspended within the bell on support rods 41, and positioned beneath the charge to reflect against the inner surface of the bell the energy of the explosive. By means of this structure I am enabled to propagate seismic waves of adequate magnitude with a charge of substantially less size.

It will be perceived from the foregoing that the basic concept of the invention is the generation of an explosion within a pocket of gas and beneath the surface of the water. Various types of equipment, capable of achieving this end, may be substituted for that illustrated herein.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. In apparatus for propagating seismic waves in underwater formations, the combination with the explosive charge, of a casing containing a gaseous medium through which the major portion of the energy released on detonation of the charge is transmitted directly to the water, means suspending said charge in said casing and in said medium, and means for detonating said charge, said casing having a volume many times that of the explosive charge, and sufficient to materially reduce the transmission through the water of wave energy having velocities in excess of 5,000 feet per second, thereby minimizing damage to marine life.

2. In apparatus for propagating seismic waves in underwater formations, the combination with the explosive charge, of a casing containing a gaseous medium, means suspending said charge in said casing and in said medium, and means for detonating said charge, said casing comprising a bell having an open bottom whereby the energy released by the explosion is reflected downwardly, said casing having a volume many

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times that of the explosive charge, and sufficient to materially reduce the transmission through the water of wave energy having velocities in excess of 5,000 feet per second, thereby minimizing damage to marine life.

3. In apparatus for propagating seismic waves in underwater formations, the combination with the explosive charge, of a casing containing a gaseous medium, means suspending said charge in said casing and in said medium, and means for detonating said charge, said casing comprising a bell having an open bottom whereby the energy released by the explosion is reflected downwardly, and baffle means within said bell and below said explosive charge to impede downward dissipation of unreflected energy.

4. In apparatus for propagating seismic waves in underwater formations, the combination with the explosive charge, of a gas releasing charge disposed in proximity to said explosive charge for forming when ignited a gaseous pocket around the latter, and means effecting in quick succession ignition of said gas releasing charge and detonation of said explosive charge.

5. In apparatus for propagating seismic waves in underwater formations, the combination with the explosive charge, of a gas releasing charge disposed in proximity to said explosive charge for forming when ignited a gaseous pocket around the latter, said gas releasing charge comprising a detonating fuse of substantial length extending about said explosive charge and having one end thereof in firing relation with the latter, and means effecting detonation of the other end of said fuse, whereby a gaseous pocket is formed, by the burning of said fuse, around said explosive charge immediately prior to detonation thereof.

6. A method of propagating seismic waves in underwater formations which includes the step of detonating an explosive charge at a point beneath the surface of the water and substantially above the bottom, and within a gaseous pocket having a volume many times that of the explosive charge, and sufficient to materially reduce the transmission through the water of wave energy having velocities in excess of 5,000 feet per second, thereby minimizing damage to marine life, the major portion of the energy released by detonation of the charge being transmitted through the gas in the pocket directly to the water.

7. The method recited in claim 6 in which the gas constituting the gaseous pocket is confined in a gas containing envelope.

8. The method recited in claim 6 in which the gas constituting the gaseous pocket is formed by the step of firing, immediately prior to the detonation of the explosive charge, a gas evolving charge in proximity to the main charge.

9. The method recited in claim 6, which includes the further step of reflecting downwardly and in a confined path the major part of the energy released by detonation of the charge.

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