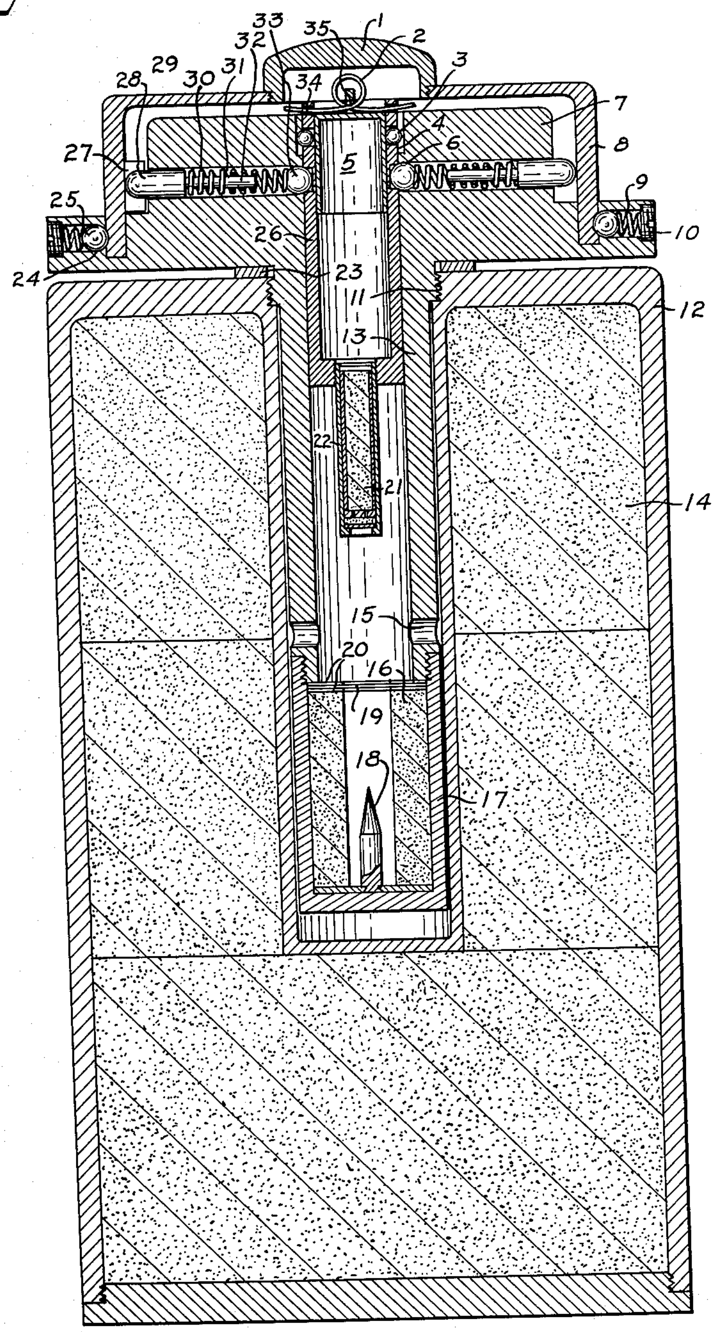
May 1, 1962 J. MENA Y VIEYRA DE ABREU **3,031,963**

PRIMING APPARATUS FOR DETONATING UNDERWATER EXPLOSIVE CHARGES

Filed March 29, 1960 3 Sheets-Sheet 1

Fig. 1



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PRIMING APPARATUS FOR DETONATING UNDERWATER EXPLOSIVE CHARGES

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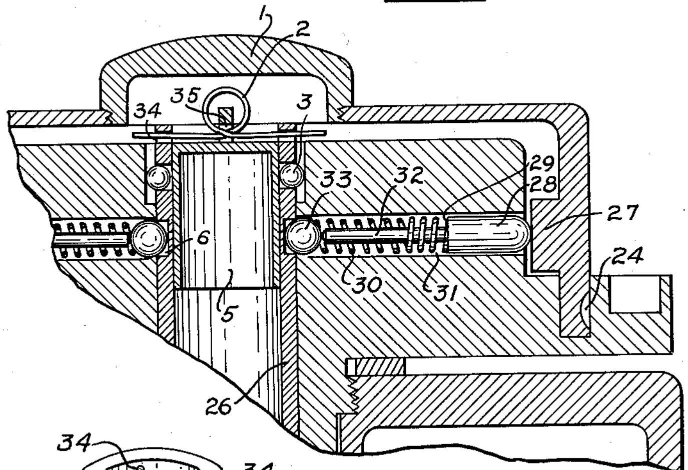
Fig. 2



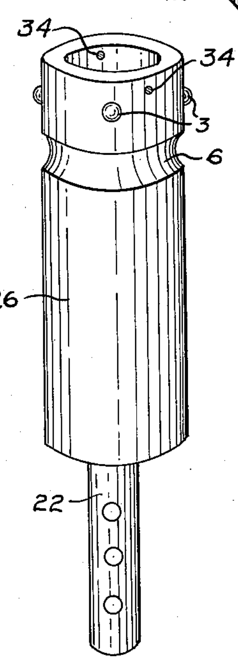


Fig. 3

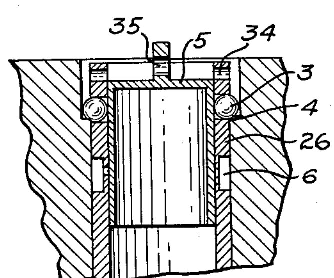


Fig. 4

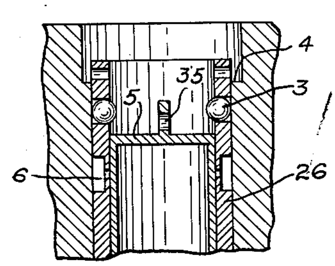


Fig. 5

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Fig. 6

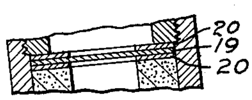


Fig. 7

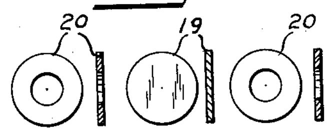


Fig. 8

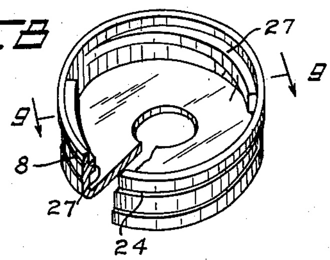
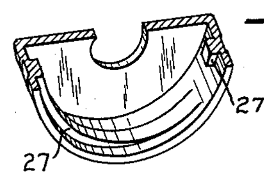


Fig. 9



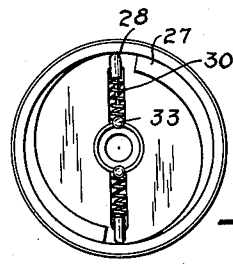
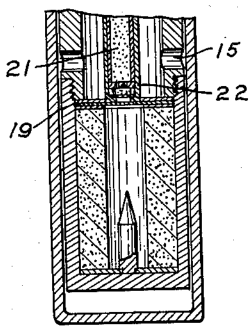


Fig. 10

Fig. 12



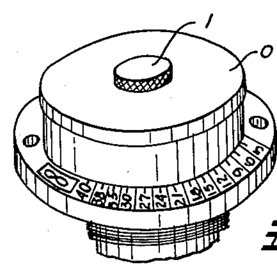


Fig. 11

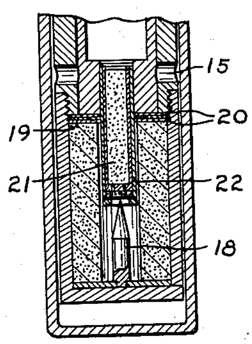
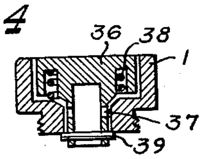


Fig. 13

Fig. 14



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PRIMING APPARATUS FOR DETONATING UNDERWATER EXPLOSIVE CHARGES

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Claims priority, application Spain Apr. 6, 1959
5 Claims. (Cl. 102—14)

The present invention relates to a new priming apparatus for underwater explosive charges, that is to say, a device for causing the explosion of an explosive charge, generally called a depth bomb, which when launched into the water explodes, upon reaching a predetermined depth. The new priming apparatus may be set to explode the depth charge at a variety of depths, such precision having been obtained in the priming apparatus that it can be regulated to explode the charge even within the range of a meter, when this is deemed convenient.

The priming apparatus thus triggers the explosion of the general charge as soon as the latter attains the desired depth. The setting mechanism is reversible at any moment, so that, when the indicator of the mechanism points to a particular depth of explosion, it is possible to increase or decrease the depth setting, or to set the mechanism to the safety position, it will suffice to rotate the setter, causing it to mark a subsequently chosen depth, or to assume the safety position, on a numbered dial without the need of any further operation.

The present invention is characterized by the simplicity of its mechanism, and also great accuracy of its performance, as confirmed by a multitude of tests in workshops and laboratories, and in all cases ratified by optimum results of tests made underwater.

Upon designing the apparatus great care has always been taken with the safety devices, both with regard to the carrying and handling operations, and also during the storage and conservation thereof.

The invention even permits the priming apparatus to be coupled to the explosive charge without any risk whatsoever, because the detonator, which initiates the explosive charge, can be kept separated from the priming apparatus, and consequently from the rest of the explosive charge, up to the precise moment of being launched into the water, inasmuch as the operation of inserting the detonator in its seating, as also the extraction thereof, only requires a few seconds.

This does not mean that there is any lack of safety after having placed the priming apparatus with its detonator inside the charge, as safety is complete at all times: the priming apparatus being provided in the first instance with a handling and carrying safety device to prevent all action while said device is incorporated in the apparatus. A second security element, called the inertia safety device is also provided, and tends to block action of the apparatus as long as the charge has not entered the water, and is not subjected to hydrostatic pressure; which, only after attaining a determined depth, will act upon this safety device, thus preparing the priming apparatus for its action.

There is also a third safety device, independent of the aforementioned, which acts upon the depth setting mechanism, which by itself blocks the mechanism, while occupying the corresponding safety position. Finally, there is a safety diaphragm to assist and reinforce the safety means previously described. Thus, a perfect security against involuntary or imprudent actions, causing serious accidents when handling explosives, is provided at all times.

Furthermore, perfect watertightness is achieved without a packing or any kind of joint, with the exception, as is logical, of a gasket between the charge and the priming apparatus.

The accompanying drawings will contribute to a better comprehension of the invention, and therein:

FIG. 1 represents in vertical mid-section the priming apparatus, coupled to a small depth charge or underwater mine;

FIG. 2 represents on an enlarged scale a part of the section shown in FIG. 1 in which the depth setter occupies the safety position, to provide handling and carrying safety;

FIG. 3 is a perspective view of the triggering element of the priming apparatus with its detonator holder;

FIG. 4 is a broken vertical mid-section of the priming apparatus illustrating the manner in which the inertia safety device blocks the mechanisms, preventing descent of the triggering element;

FIG. 5 is a similar vertical mid-section wherein the inertia safety device no longer blocks the descent of the triggering element of the priming apparatus;

FIG. 6 is a partial mid-section of the depth bomb illustrating the arrangement of the obturator diaphragm;

FIG. 7 shows the diaphragm and its fastening washers;

FIG. 8 is a perspective view of the interior of the depth setter, cut away to show an explanatory section thereof;

FIG. 9 is a partial perspective view of FIG. 8;

FIG. 10 is a bottom view of the setting mechanism, with head bolts of its latching part in the position shown in FIG. 1;

FIG. 11 is a perspective view of the setting mechanism showing the dial bearing numbers for use in setting the apparatus for action at various depths;

FIG. 12 is a broken longitudinal mid-section through the priming apparatus showing the detonator holder in contact with the obturator diaphragm;

FIG. 13 is a similar broken longitudinal mid-section illustrating the position of the parts at the moment of percussion; and

FIG. 14 is a vertical mid-section through a valve cap which may replace the upper cap shown in FIGS. 1, 2 and 11.

As will be seen in FIG. 1, the priming apparatus comprises a head **7** and a tubular extension **13** which is coupled with a depth charge or mine **12** by means of a thread **11**, whereas a gasket **23** is located between the head and the depth charge, to prevent passing of water therebetween. The general explosive charge **14** is in the inside of the depth charge.

The triggering element **26** of the priming apparatus carries at its inner end a detonator **21**, holder **22** with the detonator fitted therein to start the explosion train.

At the lower part of the tubular extension a booster **16** is situated in the form of a sleeve or stem. This is the second element of the detonator of the explosion train, and is concentric with a firing pin **18**, both elements being in a tubular case **17** joined by means of a thread with the extension **13**.

Between the booster **16** and the detonator **21** two washers **20** are mounted, which apply pressure between each other upon a piece of lead, tin-foil or any other appropriate material **19**, which thus forms a diaphragm or partition between the detonator **21** and the priming charge. FIG. 6 shows these elements on an enlarged scale, and in FIG. 7 they are shown in detail.

The triggering element **26** (FIGS. 1 and 3) is a cylinder with a ground and polished external surface corresponding to the internal surface of the extension **13**, likewise ground and polished, so that the piston will slide smoothly and without sticking along the whole length of the extension, adjusted in such a way that when lubricated it does not permit the passage of water between both surfaces. The internal surface of the element **26** is ground and polished in the same way, so that an inertia safety device **5** can slide smoothly along its inside, adjusted, however, in such a way that when lubricated water is prevented from passing between the element and the inertia safety device.

The upper part of the head is covered by a depth setter 8 (FIGS. 1 and 2), which is formed as a cover or cowl and rests with its lower part on the head 7, remaining fixed to same by means of an annular throat 24 therein in which balls 25 are engaged, the same being lodged in bores in the head and pushed inwards by the action of spiral springs 9 compressed by screws 10.

These balls, once lodged in their bores, do not escape from the bores because the material around the adjacent end of the bores is flanged inwardly at the outsides of the bores in such a manner that the diameter thus flanged is smaller than the diameter of the balls, which permits the balls to transmit pressure towards the interior, without being able to leave their bores.

Although two balls are quite sufficient to safeguard an adequate retention of the depth setter, three or four balls may be used, when the diameter of the depth setter warrants their use.

In order to separate the depth setter from the head it is sufficient to pull it strongly outwards, overcoming the resistance of the balls engaging the depth setter throat. Inversely, the depth setter will engage the head in order to be retained thereon in the above described manner. The permanent fastening of the head to the depth setter can be obtained by substituting for any of the balls 25 and its spring 9 a longer screw 10, so that same penetrates the throat 24 of the depth setter, and thus immobilises same.

In the head 7 two bores 31 are drilled which are diametrically opposed, as can be seen in FIGS. 1 and 2. In each of these bores is a ball 33, a spiral spring 30 and a bolt 28. The balls remain at the inside of the head extending a short distance into the central bore of said head. As in the former case, these balls, once lodged in their bores, can not escape out of the bores, because material about the adjacent ends of the bores is flanged inwardly in such a way that the end diameter of the bore is somewhat smaller than the diameter of the ball, which thus projects from its bore for a short distance but cannot leave the bore.

The flanges which prevent the balls from escaping from their bores may be replaced by a star-shaped or fluted profile so that the air and water can pass between the ball and the flange, thus preventing the ball from closing like a valve.

Between each ball 33 and its bolt 28 the spiral spring 30 is interposed, and is guided by the bolt stud 32. This spring bears with one of its ends against the ball and with the other against the bolt stud 29. The outer part of the bolt head is finished in spherical form in order to receive the round thrust of the depth setter 8, as the pressure of the spring forces the rounded part of the bolt 28 out of its housing.

Between the outer diameter of the bolt and the interior diameter of the bore there is sufficient clearance so that water and air can always pass, and the bolt does not act like a valve.

When the bolt 28 is pushed inwards, the spiral spring 30 is compressed and in turn pushes the ball 33 with such force as the bolt exerts upon the spring 30.

On the external surface of the triggering element 26 (FIGS. 1 and 3) there is formed an annular throat or recess into which the balls 33 project, thus securing the element 26 when compressed by their springs 30 which in turn are compressed by their respective bolts.

In the upper part of the triggering element are lodged several small balls 3, the diameter of which is greater than the thickness of the partition wall containing them, so that when introducing such part as the inertia safety device 5 into the inside of the piston, the small balls 3 project beyond the outer face of the triggering element, as can be seen in FIGS. 1, 2, 3 and 4. If, on the other hand, the balls are pushed from the outer face and nothing prevents them from entering the inside of the element, the balls will project to the inner face. In both cases these balls do not leave their partition wall because the two faces of the bore which contains them have been flanged conveniently and in such a way as to permit the balls to move inwards or outwards, but without being able to leave the wall in which they are disposed.

FIG. 4 shows the inertia safety device 5 preventing the triggering element 26 from descending, since the balls 3 pushed outwards by said inertia safety device, form a latch which impinges upon a step 4 of the head, preventing thus the descending of the element.

On the other hand, FIG. 5 shows the moment at which the inertia safety device has descended, pushed by the hydrostatic pressure, thus terminating its action on the two balls 3, which cannot act as a latch upon the step 4, because when they touch said step they slide inwards, permitting the triggering element 26 to descend.

FIG. 8 represents the inner part of the depth setter, that is to say, the piece which regulates the depth of the explosion, showing a double eccentric cam 27, which progressively extends its projection until its inner surface almost coincides with the diameter of the head. By means of this device, and when the depth setter is placed upon the head, as can be seen in FIGS. 1 and 11, upon rotating the depth setter to the right, the cams 27 slide over the rounded bolt ends 28, pushing them progressively inwards, the bolts exerting their greatest thrust when the cams are turned to bring their greatest projections against the outer ends of the bolts 28. At this moment the bolts will have performed their greatest inward stroke.

If, in this position, the depth setter is slowly turned towards the left, the effective diameters of the cams progressively increase with respect to the bolts and thus the latter, through being pushed by their springs perform the reverse stroke, that is to say, from inside to outside until they reach the zero position, where the cams do not exert any additional force upon the bolts. Thereupon, the bolts extend a maximum distance out of their bores, and a minimum force is exerted upon the balls 33 by the springs 30. Between these extreme positions of the depth setter there is a range varying between zero and the maximum thrust. Thus, the depth setter may be turned to vary the resilient force exerted upon the balls 33 whereby the hydrostatic force upon the triggering element 26 is opposed. The force, thrust or pressure which in each case has to be applied to the triggering element so as to detach same from the balls which retain it, is definitely the same as the hydrostatic pressure necessary to break the resistance of the balls which are pushed by their springs, under the action of the bolts compressed by the cam of the depth setter.

Taking the extreme values and interpolating in an appropriate manner the intermediate values, duly tested, positions of the depth setter are determined, which correspond to any depth of explosion.

On the depth setter 8 there is marked a line or arrow shown in FIG. 11, and on the rim of the head adjacent thereto there is marked another series of lines with their reference numbers, constituting the depth setter dial scale on which the corresponding positions of the depth of explosion are shown, as also the safety positions. See FIG. 11.

By moving the mark on the depth setter so that it coincides with the desired mark on the depth setter dial scale of the head, the depth of the explosion is fixed, as can be seen in FIG. 11. When set at the safety position the explosion cannot occur, because the descent of the triggering element 26 is held in fixed position as it is caught between the two balls which retain it.

FIGS. 8 and 9 show the position of the cams 27 and FIG. 10 shows also in a conventional manner the progressive increase in inward projection of both cams, which terminate in a substantially straight radial line. In this figure both bolts are represented in the zero position, which corresponds to the positions shown in FIG. 1.

The bolts have been given appropriate dimensions in order that when the depth setter rotates and reaches the maximum thrust position on the bolts on their movement towards the interior, the latter almost bear upon their respective balls, which thus being unable to move back forms latching position with the triggering element in whose throat it is engaged, securing the position of the triggering element and preventing thus any displacement along the tubular extension. In this manner a further safety position is reached by means of the depth setter itself. By only effecting an inverse rotation the outward displacement of the bolt is started, thus giving rise to new operating positions, and the safety or closing position ceases.

In FIGS. 1 and 10 the depth setter appears in the zero position, that is to say, without any thrust upon the bolts, which thus occupy the position of maximum opening, because of their displacement towards the outside by the action of their springs **30**. On the other hand, in FIG. 2 the depth setter is shown in its safety position, wherein the bolts have been pushed towards the inside by the double excentric threads of the depth setter. In this position the bolt stud **32** buts or almost buts against its ball **33**, in such a manner that the triggering element, as has been said, cannot be displaced along the bore of the tubular extension, because the balls **33**, engage its throat **6** (FIG. 2) and hold same without any possibility of escape, as the balls cannot leave the throat of the piston. This is so because the balls are pushed by their own bolts, which likewise cannot move back because the double cam of the depth setter pushes them inwards.

FIG. 1 shows, behind the left hand bolt, the cam **27** which, as can be seen in FIGS. 8, 9 and 10, decreases progressively in thickness in order to effect a simultaneous movement of the two bolts, due to rotation of the depth setter. Thus, inward movement of the two bolts **28** is effected by turning the depth setter and its cams to the right, and opposite movement of the bolts is effected as the depth setter is turned to the left to decrease the thrust of the cams upon the bolts and permit the springs **30** to move the bolts outwardly. When the depth setter has been turned to the position illustrated in FIGS. 1 and 10, the thrust of the depth setter upon the bolts substantially ceases.

FIGS. 1 and 2 show the carrying safety device, which consists of a simple spring whose two ends go through a ring **35** of the inertia safety device **5** and also through two holes **34** formed in upwardly extending flanges of the triggering element, thus preventing inward movement of the element **26**.

The operation is as follows: Assuming the priming apparatus is coupled with the charge (FIG. 1), it is sufficient to operate the depth charge, causing it to mark the depth at which the explosion is to be produced on the graduated sector. After taking away the cap **1**, the carrying safety device **2** is withdrawn by hand and the charge is launched into the water. As the latter sinks down, the thrust of the hydrostatic pressure causes the inertia safety device to advance and to pass the line of the balls **3**, as can be seen in FIG. 5. The charge continues to sink down and therefore the hydrostatic pressure increases and pushes with increasing force the triggering piston **26**, until the moment is reached that the force of the hydrostatic thrust is superior to the retentive power of the balls **3**; in this precise moment the piston is set free from the retention of the balls **3** and is launched along the tubular extension **13** with all the power of the hydrostatic pressure, which continues to act upon said piston, until it succeeds in plunging the detonator **21** against the firing pin **18** after breaking the diaphragm **19** which is interposed between the washers **20**.

A series of bores **15** facilitate the escape of air and

avoid counter-pressures when the piston and its detonator are triggered against the firing pin.

The detonation of the detonator **21** when hit by the firing pin, produces the explosion of the booster **16** and this in turn produces the explosion of the general explosive **14**.

Thus, the priming apparatus described can serve to effect the explosion of smaller depth charges, as shown in FIG. 1, suitable for harbor defense, fighting against divers or frog-men, and also against similar targets, as well as in fighting submarines at great depth, using explosive charges of high capacity, because the method of operation is the same. It is sufficient to dimension the pieces and elements of the apparatus as is deemed convenient, using adequate springs for the pressures and depths at which the devices, are to be utilized.

The depth setter which has been described above in its most elemental form, is provided with only a double eccentric cam **27** so as to act simultaneously on two bolts **28**. The depth setter may, however, be constructed with a threefold or quadruple cam to act on three or four bolts respectively, with their corresponding springs and balls. In this case the disposition of the projections **27** would not be of two sections of 180 degrees, as described in the present specification, but they would be in three sections of 120 degrees each when there are three movable elements, and in four sections of 90 degrees each when there are four movable elements. In all cases each movable element comprises a bolt **28**, a spring **30** and a ball **33**.

If it should be necessary to retain the trigger element with a greater force, so that it may be able to support higher hydrostatic pressures, a second throat can be made in the piston under the throat **6**, which, in exactly the same manner as described above, would contain a second series of balls, springs and bolts, placed respectively one for one directly beneath the first bores. The widths of the cams of the depth setter in this case are doubled so as to act simultaneously on the pairs of bolts arranged so that the depth setter, upon rotation, will operate simultaneously on all the pairs of bolts and, consequently, on all the pairs of balls. Thus the retention force exercised upon the trigger element is multiplied.

To prevent accidental detonation due to over-pressures caused mainly by the explosion of other mines or explosive charges, which could influence the piston, provision has been made for replacement of the upper cap **1**, with a valve cap, as shown in FIG. 14, in which the force of the calibrated spring **38** keeps open the valve **36**, as can be seen in the drawing, allowing the water to pass to the inside of the walls of the cap **1** and of the valve **36** through the bores **37**. The piece **39** graduates the separation between the cap and the valve.

In case of an excessive pressure taking place, the same would overcome the resistance of the calibrated spring, forcing the valve to close, which in turn would prevent the water from passing to the inside wall, thus preventing the over-pressure from reaching the piston.

Once the over-pressure ceases, the valve immediately re-opens by the action of its spring, and the water once again enters, and the priming apparatus returns to normal operation.

The foregoing description having been made, it is necessary to add that the details of the invention can vary, without any change whatsoever of the essence of same.

What is claimed is:

1. Priming apparatus for detonating an underwater explosive charge at a preset depth, said apparatus comprising a head having an axial bore and a radial bore therein, the radial bore extending outwardly from the axial bore; a triggering element slidable in the axial bore of said head, responsive to hydrostatic pressure, said element having an external circumferential throat therein; a detonator carried by said triggering element at the end thereof opposite to that subject to hydrostatic pressure; a

firing pin disposed in line with said detonator in position to be struck thereby; a locking mechanism for said triggering element comprising a ball in the radial bore of said head adapted to engage the external circumferential throat of said triggering element, a bolt in the radial bore of said head extending outwardly thereof, and a spring between said ball and said bolt to hold said ball resiliently in engagement with the circumferential throat of said triggering element; and a rotary cap carried by said head, said cap having thereon at least one inwardly extending cam surface engaging the end of said bolt extending outwardly of said head to vary the pressure upon said ball; said triggering element being held in locked position by said locking mechanism until hydrostatic pressure thereon overcomes the pressure of said spring upon said ball and moves said element within the axial bore of said head until said detonator strikes said firing pin.

2. Priming apparatus as claimed in claim 1, wherein said locking mechanism comprises a plurality of balls disposed in radial bores equally spaced circumferentially of said triggering element, a bolt for each ball and a spiral spring disposed in each radial bore between each ball and the bolt therein, corresponding inner cam surfaces formed on said rotary cap for applying pressure to each bolt, and registering markings on said rotary cap and said head calibrated to read the depth at which said apparatus is preset to be detonated.

3. Priming apparatus as claimed in claim 2 wherein two axially spaced circumferential throats are formed in said triggering element, two axially spaced sets of radial bores are formed in said head, and the inner cam surfaces formed on said rotary cap extend axially to apply pressure to two axially spaced bolts, whereby resistance to hydrostatic pressure upon said triggering element is multiplied.

4. Priming apparatus as claimed in claim 1, wherein a cap valve is screwed into said rotary cap to control sudden increases in hydrostatic pressure, said cap valve comprising a valve seat, a valve member, and a spring disposed between said valve seat and said valve member to hold said valve open, but to permit closing of said valve member upon said seat upon the existence of sudden increase in hydrostatic pressure.

5. Priming apparatus as claimed in claim 1, wherein said triggering element is cup-shaped and extends out of said head beyond the radial bores therein, the axial bore of said head having a countersunk expansion at its end beyond which said triggering element extends to form an internal shoulder in the bore, radial openings extending through the wall of said triggering element beyond the internal shoulder in the axial bore of said head, and balls in the radial openings in the wall of said triggering element, in combination with a cup-shaped inertia safety device within said triggering element pressing said balls partly into the countersunk expansion of the axial bore in said head to prevent movement of the end of said element past the internal shoulder of said head, said inertia safety device being subject to hydrostatic pressure to move into said triggering element and release said balls for inward movement to permit said element to move completely past the shoulder, and a carrying safety device fixing said inertia safety device against movement into said triggering element.

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