United States Patent [19]

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[54] **HYDROSTATIC DELAY ACTION FUSE**

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[21] Appl. No.: **64,914**

[52] **U.S. Cl.** **102/16;** 102/7

[51] **Int. Cl.** **F42c 5/00;** F42c 9/14

[58] **Field of Search** 102/7, 16

[56] **References Cited**

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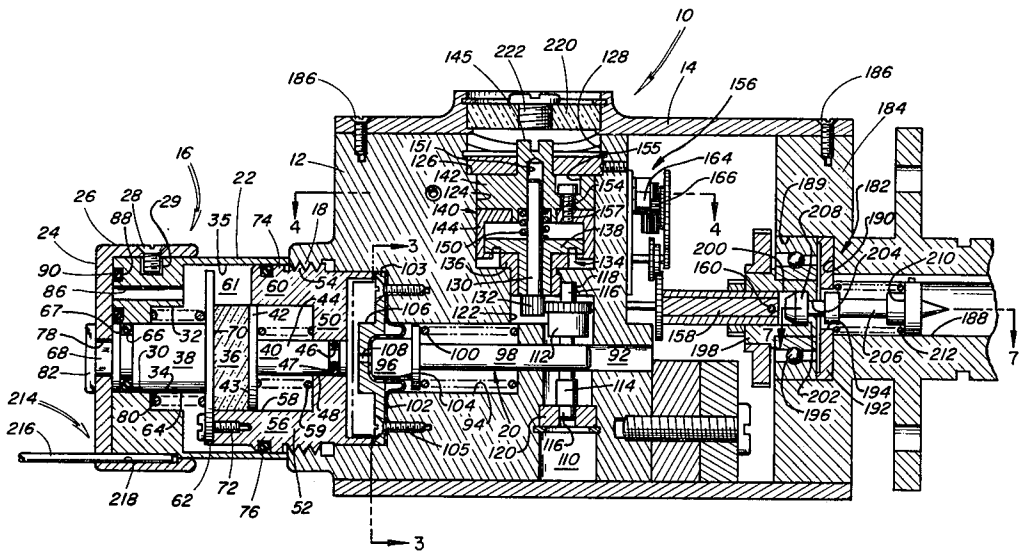
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[57] **ABSTRACT**

A hydrostatically operated fuse having a pressure sensitive movable piston fixed to a rack and pinion gear arrangement. The movement of the piston corresponding to the working depth of the fuse is transmitted by the gears to a rotating cam device which may be preset to actuate a spring driven runaway escapement mechanism at any one of a number of selected depths represented by the size of the arc through which the cam must turn. The escapement mechanism controls a firing pin release mechanism which is actuated a predetermined time interval subsequent to the escapement actuation. A soluble salt washer device prevents the pressure sensitive piston from being exposed to the ambient pressure for a predetermined time.

4 Claims, 7 Drawing Figures



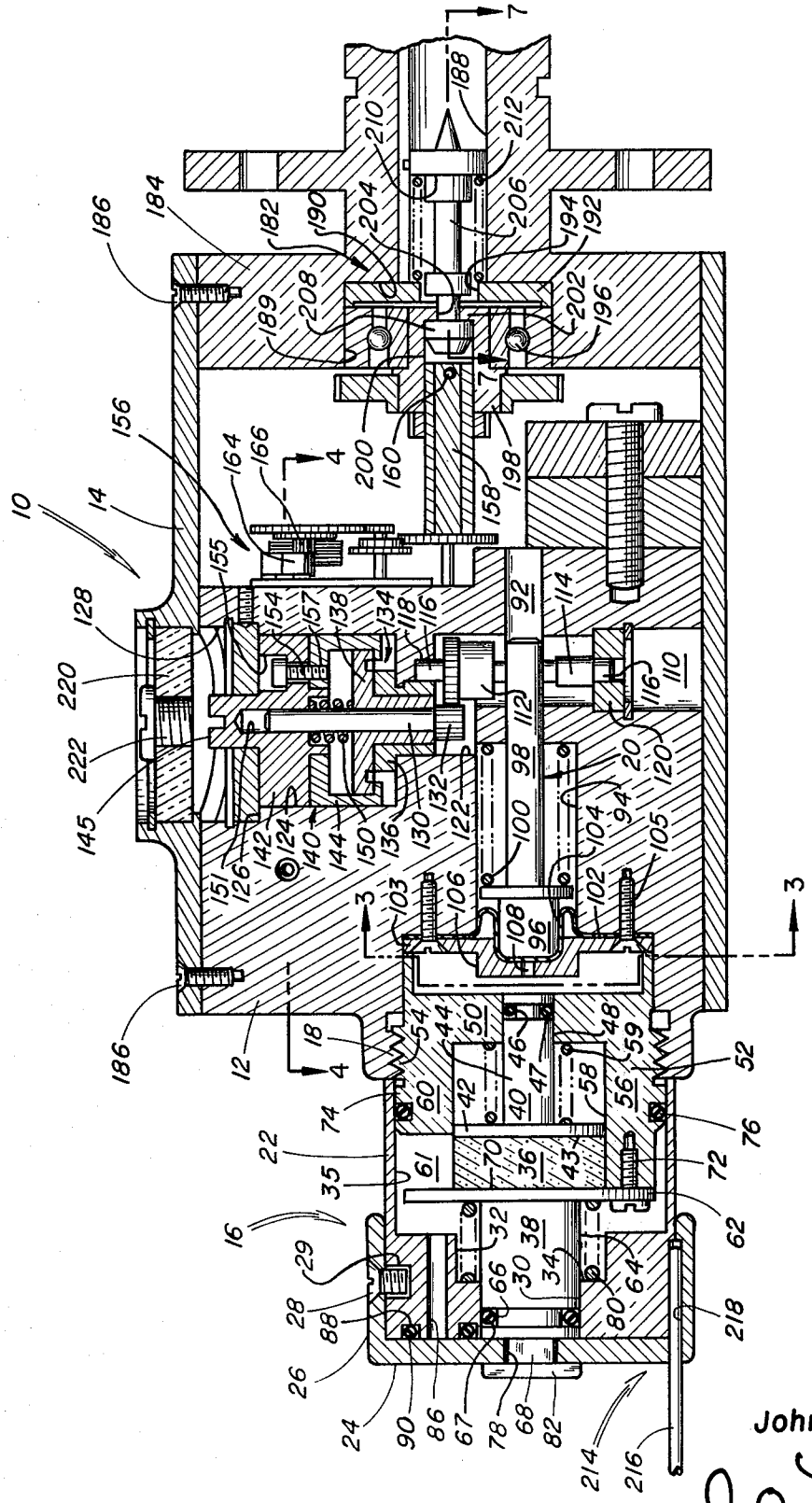


FIG. 1

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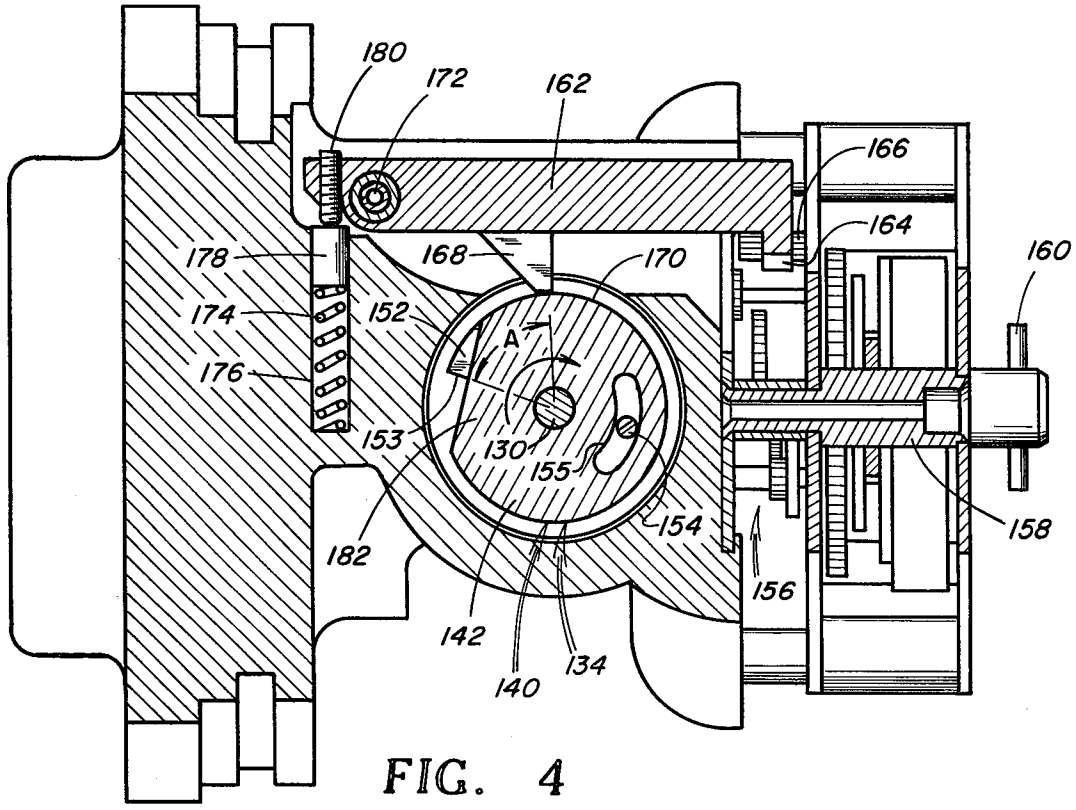

180
172
162
166
164
160
178
168
170
174
152
A
176
153
130
155
154
158
182
156
142
140
134

FIG. 4

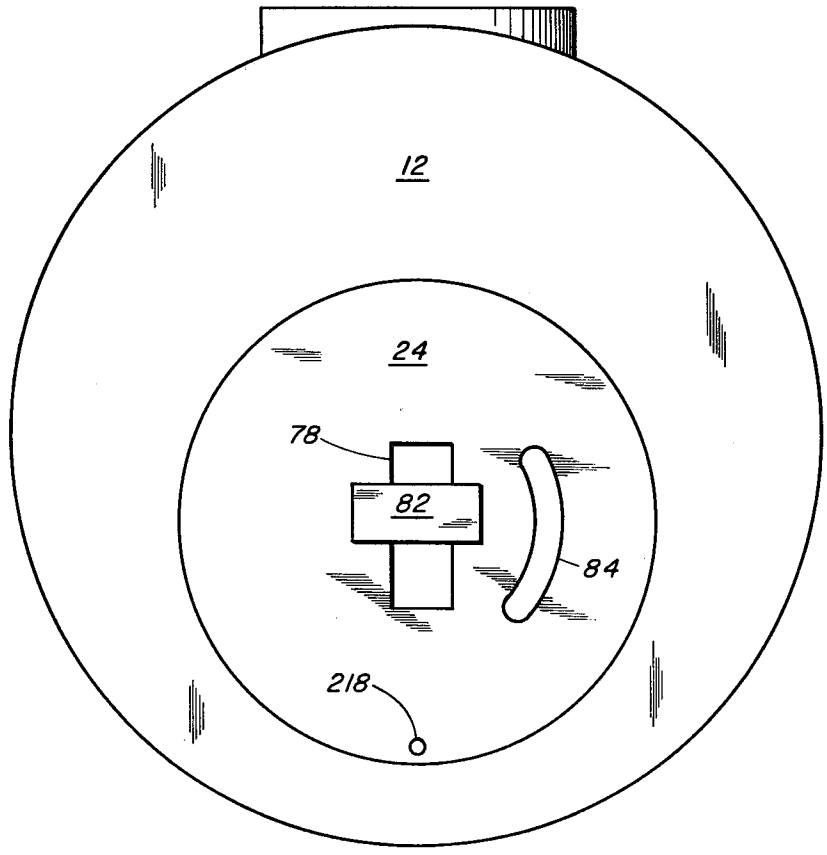

12
24
78
82
84
218

FIG. 2

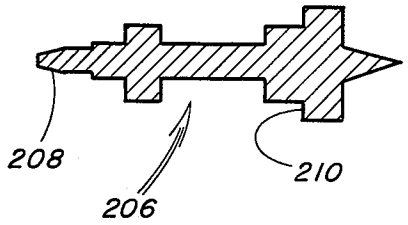


FIG. 7

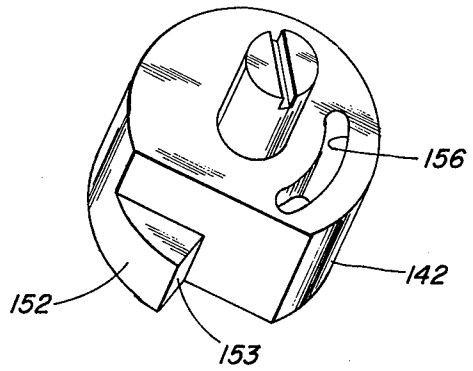


FIG. 6

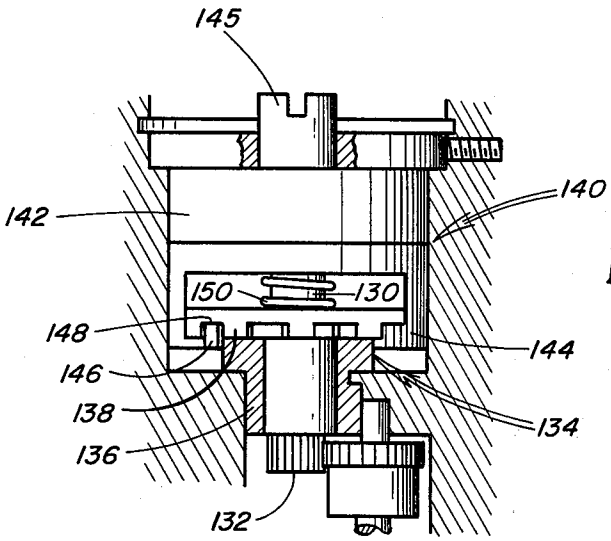


FIG. 5

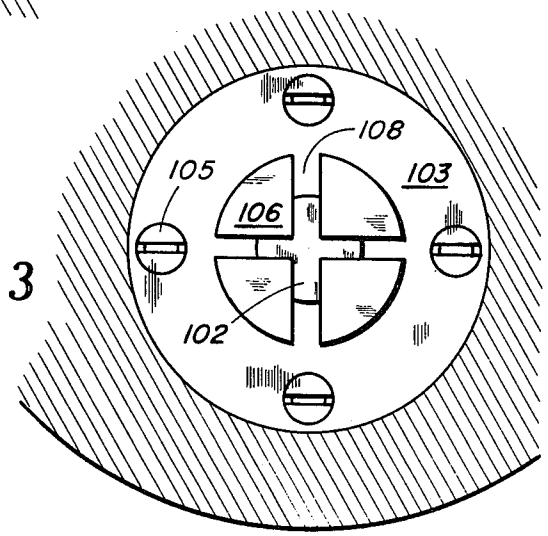


FIG. 3

HYDROSTATIC DELAY ACTION FUSE

BACKGROUND OF THE INVENTION

This invention relates generally to a delay action ordnance fuse and more particularly to an underwater fuse mechanism for setting off a charge of explosive at a predetermined future time after a predetermined depth is reached.

In anti-submarine warfare, explosive charges attached by swimmers to the hulls of moored enemy vessels, such as submarines, have proved to be extremely effective devices. In the past, the majority of these devices have been equipped with conventional hydrostatic pressure responsive type fuses adapted to be actuated when the submarine to which the device has been affixed descends to a predetermined depth. Problems have arisen, however, when a plurality of explosive devices of this type have been fastened to the hull of the submarine in longitudinal spaced relation. More specifically, as the submarine descended deeper below the surface in an angular fashion, the explosive device located towards the bow of the submarine would be exposed to the before mentioned predetermined depth prior to the devices located further aft thereof. The consequence of this is oftentimes after the first device "sees" the predetermined depth and is actuated, the submarine was not damaged sufficiently to prevent an immediate cessation of the dive and a subsequent surfacing of the vessel. As a result, the remaining explosive devices would remain unactivated.

It would appear to be desirable, therefore, to provide an explosive device with a fuse which, after the predetermined depth is attained, delays the initiation of the charge for a fixed amount of time. The provision of such a time delay would allow the entire submarine and the plurality of explosive devices fixed thereto to exceed the predetermined depth level and thereby assures the efficacious explosive detonation of all the devices.

SUMMARY OF THE INVENTION

Accordingly, one object of this invention is to provide a new and improved fuse apparatus for underwater weapons.

Another object of the invention is the provision of an improved hydrostatic pressure responsive fuse.

Still another object of the instant invention is to provide a pressure responsive fuse having a variable depth setting capability.

A further object of the present invention is to provide a new and improved pressure responsive fuse which will not function for a predetermined time interval after the fuse has been exposed to a predetermined hydrostatic pressure.

Briefly, in accordance with one embodiment of this invention, these and other objects are attained by providing a fuse with a pressure sensing mechanism adapted to actuate a release and depth setting mechanism at any one of a number of possible depths at which time a delay timer mechanism is initiated by the release mechanism. After a predetermined amount of time elapses, the delay timer actuates a firing pin release mechanism which permits a firing pin to be moved with great velocity into an explosive charge.

BRIEF DESCRIPTION OF THE DRAWING

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a side view, in full section, of the fuse according to the present invention;

FIG. 2 is a front view of the fuse;

FIG. 3 is a sectional view on the line 3—3 of FIG. 1;

FIG. 4 is a sectional view on the line 4—4 of FIG. 1;

FIG. 5 is a side view of the depth setting mechanism in partial section;

FIG. 6 is a perspective view of the dial and release cam of the present invention; and

FIG. 7 is a cross-sectional view of the firing pin taken along line 7—7 of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings wherein like reference characters designate identical or corresponding parts throughout the several views, and more particularly to FIG. 1 thereof, the hydrostatic delay action fuse of the present invention is shown as including a fuse housing 10 formed of a generally cylindrical body portion 12 surrounded by a cover 14 and a salt washer housing generally denoted at 16 threadedly connected to one end of fuse housing 10 by threads 18. Body portion 12 houses a hydrostatic pressure sensing mechanism 20 as will be described in more detail hereinafter which is prevented from being exposed to ambient hydrostatic pressure by the apparatus contained in salt washer housing 16.

The salt washer housing 16 includes a transparent cylindrical housing cover 22 and a circular cap 24 attached thereto having a flanged rim 26. A set screw 28 cooperates with the rim 26 and sits within an annular groove 29 in housing cover 22 thereby permitting relative angular movement while prohibiting relative longitudinal movement between cap 24 and housing cover 22 for reasons to be more fully discussed hereinafter. Cover 22 includes three axial internal bores, the smallest of which, bore 30, opens into the end of the housing immediately adjacent cap 24. A counterbore 32 of larger size than bore 30 cooperates therewith, thereby forming an annular shoulder 34 and a second counterbore 35 communicates with counterbore 32 at one end thereof and opens into the end of housing 22 furtherest from circular cap 24. A soluble washer disc 36, which may be made of any one of a number of soluble materials, such for example, as a mixture of 80 percent bicarbonate and 20 percent sodium chloride compressed at 8,000 psi, is fixedly positioned within salt washer housing 16 by the cooperation of a fixed piston 38 and an opposed movable piston 40. Piston 40 includes a flat circular plate 42 which is positioned against a side 43 of the soluble washer 36 and is connected to an elongate shaft 44 having an annular groove 46 containing an O-ring seal 47 therein. The shaft 44 is slideably positioned in a bore 48 contained within a transverse wall 50 of a cylindrical piston housing 52 having a partially externally threaded portion 54 fixedly connectable to the threads 18 of body portion 12. Cylindrical wall 56 of piston housing 52 defines an internal piston bore 58 in which the piston plate 42 may slide. A compression spring 59 biases plate 42 against side 43 of the soluble washer 36. The soluble washer 36 is retained through-

out a substantial portion of its circumference by the inner surface of bore **58**. The cylindrical wall **56** includes a relatively shortened portion as shown at **60** forming a slot **61** in piston housing **52** and as a consequence, the circumference of the soluble washer **36** adjacent to the formed slot **61** is not physically constrained in any way.

Fixed piston **38** includes a circular flat plate **62** and a cylindrical shaft **64** connected thereto having an annular groove **66** formed therein containing a seal **67**. A second cylindrical shaft **68** of reduced diameter is formed integrally with the first shaft and positioned at the end thereof. Plate **62** is fixed in abutting relationship against side **70** of soluble washer **36** by conventional means such as screw **72** which is threadedly fastened into wall **56** of piston housing **52**.

Piston housing **52** includes a circumferentially extending enlarged portion **74** substantially adjacent to threaded portion **54** which has a circumferential groove formed therein for retaining a seal member **76**. The salt washer housing cover **22** is fitted over the enlarged portion **74** of piston housing **52** with the shaft **68** of fixed piston **38** extending through a rectangular central opening **78** in the circular cap **24**. The entire salt washer housing **16** is biased in a direction opposite from body portion **12** by means of a compression spring **80** positioned about shaft **64** in a compressed state and whose ends abut against shoulder **34** and piston plate **62**. A rectangular head **82** fixed to shaft **68** retains the salt washer housing **16** in place against the force of spring **80** as best seen in FIG. **2**. Cap **24** further has formed therein an arcuate opening **84** which upon rotation of the cap **24** to an appropriate position will cooperate with a bore **86** formed in housing cover **22** for reasons to be discussed in greater detail hereinafter. Housing cover **22** has an annular groove **88** formed in its end adjacent the inner surface of cap **24** and surrounding the bore **86** in which an O-ring seal member **90** is positioned. The necessity for the sealed bore **86** and cooperating opening **84** will become more apparent when the operation of the invention is more fully described hereinafter.

Positioned immediately behind the transverse wall **50** of piston housing **52** in body portion **12** is the pressure sensing mechanism **20**. A longitudinally directed bore **92** is formed within body portion **12** and cooperates with a cylindrical cavity **94** formed in a forward position of body **12**. Movably positioned within cavity **94** is a piston **96** integral with a rack **98** which slides within bore **92**. The piston and rack assembly is biased towards the salt washer housing **16** by a spring **100** whose ends bear against the rearward wall of cavity **94** and a shoulder portion on piston **96**. A diaphragm **102** is fastened to the front edge of body portion **12** by a circular retaining member **103** which substantially encloses the piston **96** within the diaphragm as at **104**. Retaining member **103**, which may be fastened to body portion **12** by screws **105**, includes a central substantially circular raised portion **106** which serves to restrain the piston **96** against the force of spring **100**. Two diametrical slots **108** are formed at right angles to each other which effectively expose diaphragm **102** to the ambient environment present between transverse wall **50** and retaining member **103** to be discussed in greater detail hereinafter.

Intersecting bore **92** at right angles thereto is a transverse cylindrical cavity **110** opening into the outer surface of body portion **12**. Contained within cavity **110** is a pinion and spur gear assembly **112** having a shaft **114** whose ends **116** are rotatably mounted in a bore **118** and cylindrical bearing member **120** affixed within cavity **110**.

Axially offset from cavity **110** and cooperating therewith is a cylindrical bore **122** which opens into an axially aligned counterbore **124** of greater diameter and which defines an annular shoulder **126** in cooperation with a second counterbore **128**. Rotatably positioned within bore **122** and extending into counterbore **124** is a shaft **130** having a gear **132** connected at one end thereof which cooperates with the pinion and spur gear assembly **112**. Fixed to the lower portion of shaft **130** and adapted to rotate with the shaft is a female sprocket assembly **134** including a bearing **136** and a disc-shaped female sprocket **138**. A male sprocket assembly **140** slideably mounted on the upper portion of shaft **130** cooperates with the female sprocket **138** in any one of a number of selected positions. The male sprocket assembly **140** includes a dial and release cam **142** to be described presently and a male sprocket **144** fixed thereto. The male sprocket **144** is of a substantially cylindrical shape having on its lower rim an upwardly formed tooth **146**. The female sprocket **138** includes a series of circumferentially spaced, tooth receiving slots, such for example, as **148**. The male sprocket assembly is biased in an uppermost position by spring **150** which cooperates with dial and release cam **142** to allow the tooth of male sprocket **144** to mesh with the slots of the female sprocket **138** in a positive fashion. It should be apparent, therefore, that the male sprocket **144** can be selectively engaged with the female sprocket **138** in any one of a number of angular positions and when so engaged, will move as an integral portion thereof. To vary the position of the male sprocket assembly **140** with respect to the female sprocket assembly **134**, it is only necessary to depress the male assembly **140** against spring **150** thereby disengaging the teeth from their slots while turning the male sprocket assembly to a new position. The reasons for so doing will be made apparent hereinafter.

The dial and release cam **142** is positioned on shaft **130** above the male sprocket **144** and is of a disc-shape having a substantially circular cross-section with a centrally disposed cylindrical bore **151**. A centrally disposed slotted protrusion **145** is also provided for reasons to become apparent later. The functional contour of cam **142** is formed by slicing a portion of the disc along an imaginary chord leaving only a lower one-quarter of the material **152** remaining forming a step **153** as best seen in FIG. **6**. The cam **142** is normally fixed to the male sprocket **144** by means of a set screw **154** which is positioned within an arcuate groove **155** in the cam which overlies a threaded bore **157** in the male sprocket **144**. It should be evident, therefore, the dial and release cam **142** may be fixed to the male sprocket **144** in any one of a number of positions by merely loosening screw **154**, rotating cam **142** and retightening the screw. This feature is utilized for precise calibration techniques which will be more fully explained in the description of the operation of the invention hereinafter. Cam bore **151** extends above the end of shaft **130** so as to permit the male sprocket **144** to be depressed as discussed hereinbefore.

Referring now to FIG. **4**, it will be seen that substantially adjacent to and rearward of male and female

sprocket assemblies **140** and **134** is a conventional spring driven runaway escapement mechanism **156** whose details will not be described since of a conventional nature. Directly geared to the escapement is a rotatably mounted shaft **158** having a key **160** comprising a rod integrally mounted perpendicular to the axis thereof. When escapement **156** is in its energized state, that is, when the mainspring has been wound, the mechanism is normally prevented from operating by an elongate release arm **162** which includes a downward facing projection **164** at the rearward extremity thereof which contacts escapement gear **166** thereby preventing its rotation. Release arm **162** is positioned alongside dial and release cam **142** transverse to the longitudinal axis thereof and further includes a follower **168** attached to the release arm midway along the length thereof which is normally in contact with the circular surface **170** of cam **142.** A pivot **172** is provided at the forward end of release arm **162** and the arm is biased in a clockwise direction as seen in FIG. **4** by virtue of a compression spring **174** housed in a bore **176.** A cylindrical member **178** is fastened to the end of the spring and cooperates with a threaded member **180** positioned at the end of arm **162** thereby effecting the biasing force.

When the follower **168** of release arm **162** is in contact with the circular surface **170** of the dial and release cam **142,** the projection **164** is forced into contact with the escapement gear **166** and thereby prevents the operation of the escapement mechanism **156.** However, it should be apparent that if cam **142** rotates in the direction of arrow **182,** to be more fully described hereinbelow, the step **153** in the release cam will align with the follower **168** on the release arm **162.** As a result of the biasing discussed hereinbefore, the release arm pivots in a clockwise direction thereby unlocking the spring driven escapement **156.**

Referring again to FIG. **1,** a firing pin release mechanism, generally denoted as **182,** is shown as positioned within a firing pin release housing **184** which is fixed to an end of cylindrical cover **14** by conventional means, such for example, as screws **186.** The release housing **184** has formed therein an internal cylindrical bore **188** which cooperates with an axially aligned counterbore **189** forming a shoulder **190.** A circular wall **192** having a central opening **194** is fixed in abutting relationship to shoulder **190.** Immediately adjacent to wall **192** a conventional ball bearing **196** is positioned within counterbore **189.** Fitted rotatably within the inner race of bearing **196** is a cylindrical firing pin retaining drum **198** having a central cylindrical bore **200** which extends the length thereof and an inwardly disposed lip **202** at one end which defines a rectangularly shaped opening **204.** The bore **200** in the retaining drum **198** is adapted to fixedly receive key **160** of shaft **158** by providing matching openings (not shown) for the key.

Slidably positioned within and extending the length of bore **188** and counterbore **189** is a firing pin **206** which is provided with transversely extending rectangular locking arms **208** at one end and an annular shoulder **210** in substantial proximity to the other end thereof. A compression spring **212** is positioned about the firing pin **210** which abuts the wall **192** and annular shoulder **210** of the firing pin. The spring **212** is held in its compressed position by positioning firing pin **206** such that the locking arms **208** are within the retaining drum **198.** It is obvious that as long as the opening **204** in the retaining drum **198** is not aligned with the locking arms **208,** the firing pin **206** will be held in position despite the biasing force of spring **212.**

In operation, a swimmer will attach an explosive mechanism incorporating the fuse of the present invention to the hull of an enemy vessel, such as a submarine, while moored. Initially, a primary locking device **214** including an elongate rod **216** positioned in a bore **218** formed mutually in the housing cover **22** and circular cap **24** to prevent relative angular movement therebetween is removed by the swimmer. The cover **22** and cap **24** are thereafter removed by rotating the cap in either a clockwise or counterclockwise direction. As this is done the arcuate opening **84** (FIG. **2**) in the cap **24** will align itself with bore **86** in cover **22** thereby allowing water to enter within and equalize the hydrostatic pressure on either side of the cap. When head **82** is aligned with opening **78,** the compression spring **80** pops the cover and cap off the piston housing **52** thereby exposing the soluble washer **36** to the external atmosphere. The time required to dissolve the salt washer **36** varies depending on water temperature and current, however, it usually should require a minimum of 30 minutes to dissolve in water at a temperature of 90° F with a 1 knot current. As the washer **36** dissolves, the movable piston **40** advances towards the piston plate **62** of fixed piston **38** propelled by the force of spring **59.** After the soluble washer **36** has dissolved a predetermined amount, the portion of piston plate **42** of the movable piston **40** which had been cooperating with the shortened wall portion **60** of piston housing **52** moves to a position opposite slot **61** thereby allowing the free entry of water into piston bore **58.** By the time soluble washer **36** has almost completely dissolved, the seal formed by the O-ring **47** cooperating within bore **48** is broken by virtue of the O-ring having been removed from the bore. The ambient pressure will then be allowed to act on the diaphragm **102** of pressure sensing mechanism **20.**

As the ambient pressure acts on the diaphragm **102** and increases due to increasing depth of the submarine, the piston **96** and rack **98** affixed thereto are moved in bores **92** and **94.** The compression spring **100** opposes the force on the piston **96** transmitted by the diaphragm **102** and thereby controls the amount of piston movement for each increment of pressure increase. The linear piston movement is transmitted to the piston and spur gear assembly **112** by rack **98** where it is transformed to rotary motion. The rotation of pinion and spur gear assembly **112** is then transmitted to the male and female sprocket assemblies **140** and **134** through gear **132.**

It is to be noted that the escapement mechanism **156** has been, during the entire sequence described above, in a locked position and maintained therein by the locking effect of projection **164** of release arm **162** on escapement gear **166.** As discussed hereinbefore, as long as release arm follower **168** rides on the circular surface portion **170** of dial and release cam **142,** the escapement will remain in a locked position.

The female sprocket **138** is driven directly by gear **132** with the amount of rotation thereof determined by the size of the pressure increased as reflected by the movement of the pressure sensing mechanism **20.** As described hereinbefore, the female sprocket **138** is slotted, as at **148,** and each slot represents a depth setting. The male sprocket **144** is driven by the female sprocket

when they are engaged and the dial and release cam **142** is locked into the male sprocket **144** and rotates therewith during operation. During rotation, follower **168** on the release arm **162** rides on the cam **142.** When the follower **168** is aligned with the step **153** on the cam **142,** the release arm **162** pivots under the force of spring **174** (FIG. **4**) in a clockwise direction thereby freeing the escapement gear **166** of the locking effect of projection **164** thus allowing the escapement mechanism **156** to begin operation.

The pressure at which release occurs is determined by the arc, such for example, as A in FIG. **4,** through which the release cam **142** must rotate in order to align the step **153** in the release cam with the follower **168.** A change in depth setting is accomplished by increasing or decreasing the arc. This is accomplished by depressing the dial and release cam **142** thus disengaging the male and female sprockets and rotating the male sprocket **144** with the attached cam **142** independent of the female sprocket **138.** The male sprocket assembly **140** is made accessible through a window **220** in the cover **14** by removing a seal screw **222.** One need merely remove screw **222,** insert a tool such, for example, as a screwdriver into the slot in protrusion **145,** depress the male sprocket assembly **140,** and set it to a new depth setting by suitably rotating and repositioning it with respect to female sprocket **138.**

When the spring driven runaway escapement **156** is unlocked, the key **160** revolves at a predetermined rate and causes firing pin retaining drum **198** to rotate. The time required to rotate the firing pin locking drum **198** into the firing pin release position is controlled by the runaway escapement **156.** Firing pin release is accomplished when the opening **204** in the retaining drum **198** is rotated into alignment with the locking arms **208** on the firing pin **206.** It is to be noted that once the escapement release is accomplished should the submarine try to resurface, the release arm **162** has locked the male sprocket assembly **140** into position thereby preventing the relocking of the escapement.

Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described herein.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A hydrostatic delay action fuse comprising:

a substantially cylindrical fuse housing;

means positioned within said housing for sensing changes in hydrostatic pressure;

means connected to an end of said housing for preventing said pressure sensing means from being exposed to ambient pressure for a predetermined time;

sprocket means, including a female sprocket geared to said pressure sensing means and a male sprocket adapted to mesh with said female sprocket in one of a plurality of positions and a compression spring normally biasing said male sprocket into meshed contact with said female sprocket, for converting changes in the ambient pressure into rotary motion;

a firing pin slideably held within said housing;

release means operably connected to said firing pin for controlling the operation thereof;

time delay means cooperatively associated with said firing pin release means for delayably actuating said release means a predetermined time interval after the initiation of the timing sequence of said time delay means; and

means connected to said sprocket means and rotatable therewith for initiating said time delay means in response to a predetermined rotation of said sprocket means.

2. A hydrostatic delay fuse as recited in claim **1** wherein said means for initiating said time delay means includes a cylindrical cam fixed to said male sprocket and a pivoted elongate release arm adapted to pivot from a first position wherein said time delay means is in its uninitiated state to a second position wherein said time delay means has been initiated, said arm and said cam having means cooperating to permit pivoting of said arm to its second position when said arm is in contact with one position of said cam only and to maintain said arm in said first position at all other times.

3. A hydrostatic delay action fuse according to claim **2** wherein said cam includes manually operable means integral therewith for varying the angular location of said one position of said cam with respect to said release arm by disengaging said male and female sprockets and revolving said male sprocket and the associated cam with respect to the female sprocket.

4. A hydrostatic delay action fuse according to claim **3** wherein said pressure exposure preventing means comprises a movable piston having a normally watertight seal at one end thereof and a water soluble salt washer adapted to be exposed to the ambient environment, said washer positioned in abutting relationship to said piston to prevent the movement thereof and consequent opening of said seal.

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