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Davidson

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[54] **UNDERWATER RELEASE DEVICE**

[76] Inventor: **William M. Davidson,** Box 74, Mountain Lakes, N.J. 07046

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[52] **U.S. Cl.** **307/116,** 102/13
[51] **Int. Cl.** **H01h 35/00**
[58] **Field of Search** 102/10, 13, 19.2; 307/116, 119

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Primary Examiner—Herman J. Hohauser
Assistant Examiner—William J. Smith
Attorney—William M. Davidson

[57] **ABSTRACT**

A device for releasing load tension from submerged objects, such as a mooring line in tension, which device may be remotely operated to effect release and is comprised of an outer container, load attachment means, a stored energy source, a thermally fusible link element, switching components, sensors, such as attitude or pressure depth, and a force-multiplying mechanical release mechanism wherein the stored electrical energy is released upon command to fuse said link element and thereby permit said mechanical release mechanism to uncouple one of said load-attachment devices.

5 Claims, 5 Drawing Figures

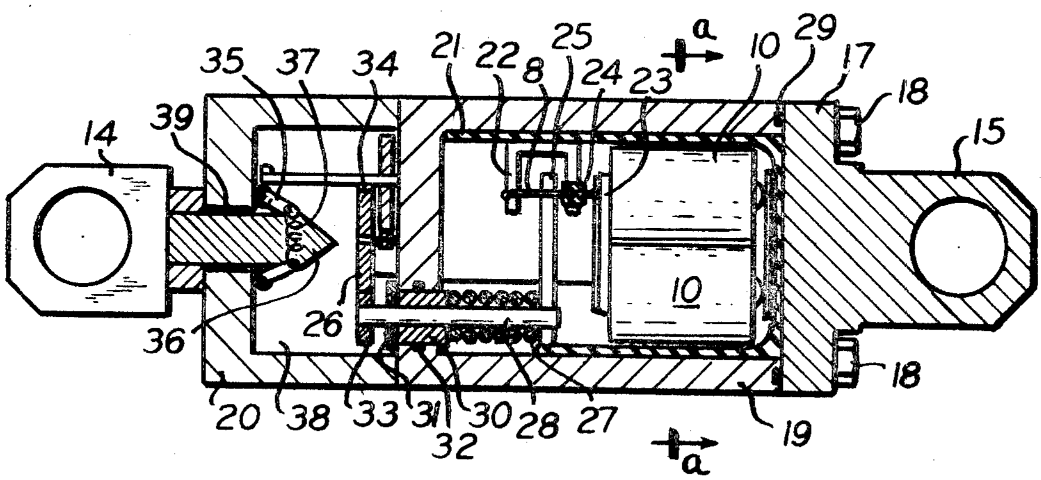

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FIG. 1.

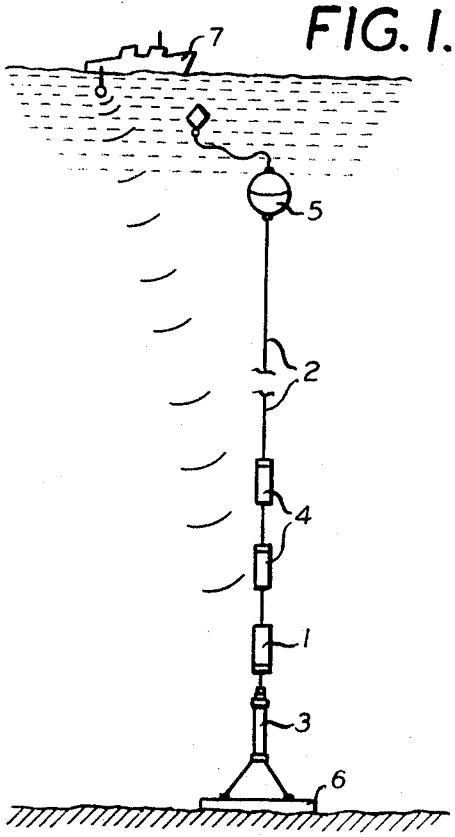


FIG. 2.

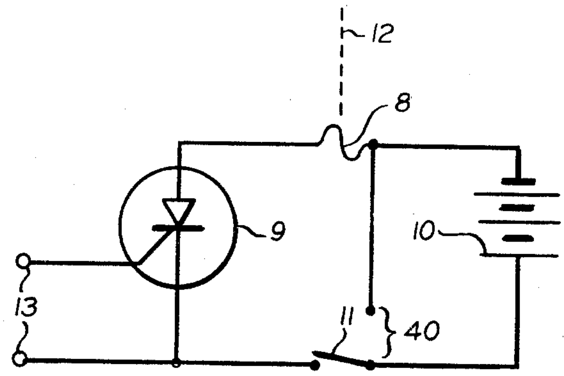


FIG. 3c.

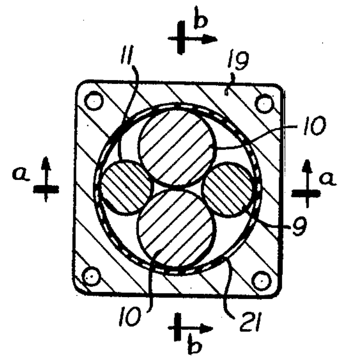


FIG. 3a.

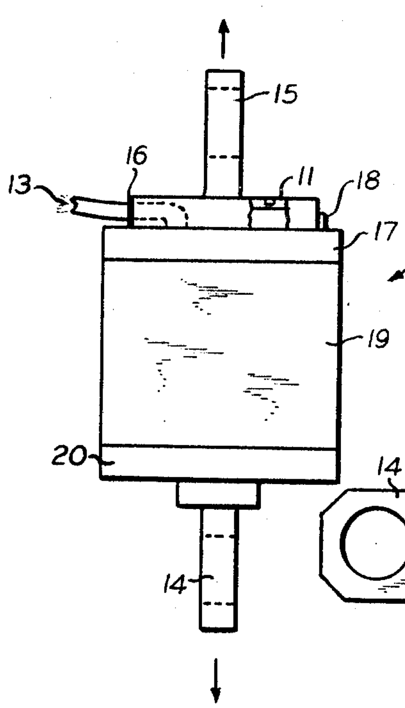
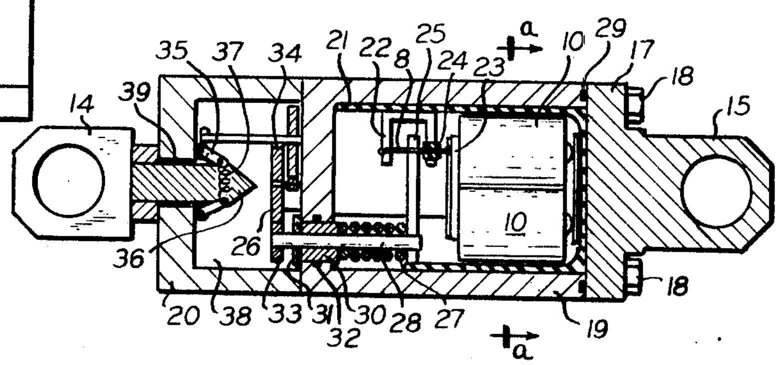


FIG. 3b.



UNDERWATER RELEASE DEVICE

This invention relates to an underwater release device which may be used as a part of a mooring system or, optionally, may be incorporated as an integral component of another device that requires a release mechanism in order to perform its function. Operation of the release device can be controlled by a variety of means, including, manual switch, attitude change, pressure depth, electric cable, time delay or acoustic receiver.

Other release devices, currently in use, include explosive mechanisms, shear pins and motor-driven power trains. Explosive devices require special care and handling for storage, transport and operation and, in many instances, interfere with swimmers or underwater acoustic devices. The operation of both the explosive and motor-driven types of release devices require transmission of electric current by wire to the release devices, both of which require substantial current or power.

This invention provides a non-explosive release device that can be refurbished in the field by replacement of the fusible link element. Further, the release can be operated in a variety of ways with low input signal power; in one instance, a brief pulse current of 10 milliamperes is sufficient to operate the release device. These advantages are achieved through the use of low-impedance switches in combination with low-impedance storage devices for electrical energy, such as nickel cadmium batteries or capacitor discharge elements. All of the electrical components are isolated from sea water and the underwater environment by means of a pressure-sealed external container or housing.

One object of this invention is to provide an underwater release device that is simply constructed, compact, reliable and safe to store and handle as well as low in cost.

Another object of this invention is to provide a release device that does not involve the use of explosives and can be operated in the same area with personnel or with other underwater acoustic devices.

Another object of this invention is to provide a release device that contains its own stored electrical energy as required for its operation so that it can be used and operated independently from external sources of power even after six months to a year in the water environment.

Another object of this invention is to provide a release device that can be readily altered to permit control by a variety of means, either remotely or manually, including, manual switch, attitude change, pressure depth, electric cable, time delay or acoustic receiver.

Still another object of this invention is to provide a release device that can be refurbished and reused in the field without complex tooling or equipment being required.

Other objects, advantages and novel features of this invention will become apparent from the following description of the invention when considered in conjunction with the accompanying drawings wherein:

FIG. 1 illustrates pictorially one use of this invention as a cable release when operated in combination with an acoustic receiver for recovery of a moored array of instruments.

FIG. 2 presents an electrical schematic wiring diagram for the essential elements of this invention and their electro-mechanical functional relationships.

FIG. 3*a* shows a plan view of a typical release device completely assembled. FIG. 3*b* shows a cross-section view at location *b—b* illustrating the internal mechanisms. FIG. 3*c* is a cross-section view at location *a—a* to further illustrate the power-pack section.

Referring in greater detail to the drawings, one application of the release device is illustrated in FIG. 1. Release device 1 is coupled at its upper end to plastic rope 2 and at its lower end to acoustic receiver 3. Current meter array 4, also secured to rope 2, is suspended at depth by means of subsurface buoy 5 which furnishes buoyancy to maintain rope 2 in tension against mooring 6 and the negative buoyancy of current meters 4. When it is desired to recover instrument array 4, surface ship 7 transmits an acoustic signal through the water to acoustic receiver 3 which, in turn, transmits an electrical pulse by direct wire means (not shown) to release device 1. Release device 1 converts the electrical pulse signal into mechanical action that uncouples release device 1 from acoustic receiver 3, thus allowing buoy 5 to lift meter array 4 to the ocean surface for recovery operations by surface ship 7.

FIG. 2 shows schematically the electro-mechanical elements of release device 1. Fusible link 8, which may be made of fine wire, such as stainless steel wire 3 to 10 mils in diameter, is electrically connected between the anode of low-impedance operating switch 9, which may be either a silicon controlled rectifier or a mercury switch, and one terminal of low-impedance energy source 10, which may be nickel-cadmium storage batteries or capacitor elements. The electrical circuit between energy source 10 and the cathode of operating switch 9 may be completed by arming switch 11, which may be a mechanically-operated single-pole, single-throw switch having low impedance. Closing operating switch 9 causes discharge of current from energy source 10 through arming switch 11 and fusible link 8; current flow through link 8 causes it to fuse rapidly and free mechanical release element 12. Operating switch 9 may be closed by signal from remote control source 13, such as an acoustic receiver or external cable, which furnishes a small gating current in the order of 10 milliamperes. If operating switch 9 is a mercury switch, it can be closed by tilting the switch through a prescribed angle of tilt in any direction from vertical. Terminals 40 can be used either to measure the condition of energy source 10 or for recharging purposes simply by replacing switch 11 with a test plug designed for such purposes.

FIG. 3 illustrates a typical embodiment of release device 1 in electro-mechanical structural form. FIG. 3a shows an external plan view of release device 1 with attachment devices 14 and 15 for cable attachment, wherein terminal 14 can be released upon command. Arming switch 11 and electrical feed-through 16 are mounted on end plate 17 which is secured to housing 19 by bolts 18.

Internal components of release device 1 are illustrated by cross-section view *b—b* in FIG. 3b. Housing 19, designed as a pressure vessel to withstand hydrostatic pressure, contains power pack 21 and rotary actuator 26. End plate 17 and seal 29 together with housing 19 form a complete pressure vessel together with suitable seals for electrical feed through 16 and rotary shaft 28. Power pack 21 includes energy source 10, which as illustrated consists of two nickel-cadmium storage batteries, a solid-state operating switch 9, arming switch **11**, control source **13** with electrical feed through **16**, fusible link **8**, supported between ground support arm **22** and bus bar **23**. Link **8** is electrically insulated from support arm **22** by means of insulator **24**. Bus bar **23** connects batteries **10** in parallel at their anodes. Electrical connections (not shown) are provided to complete the electrical circuitry of power pack **21** so that arming switch **11**, operating switch **9**, control source **13** and link **8** are connected as illustrated in FIG. **2**. Power pack **21** is inserted in housing **19** so that link **8** engages and restrains lever arm **25** of rotary actuator **26** against the torque of torsion spring **27**. Shaft **28** of actuator **26** is sealed to gland **30** by means of seal **31**. Gland **39** is sealed to housing **19** by means of seal **32**. Pinion gear **33**, attached to the end of shaft **28**, engages spur gear **34** which drives latches **35** through a suitable gear train designed for torque multiplication. Latches **35** are held in engagement with detents in pin **36** by means of tension springs **37**. Cavity **38** within housing **20** is open to sea water through hole **39** which provides clearance for pin **36** attached to release terminal **14**. A multiplicity of release mechanisms can be applied for the release of pin **36** employing mechanical advantage toward the end that the force required to restrain lever arm **25** is only a few pounds, while the tensile force applied to cable release terminal **14** can be several tons. Further, a preferred alternate design approach would be to incorporate the gear train, including gears **33** and **34**, within the protective enclosure of housing **19**.

FIG. 3*c* shows a cross-section view at location *a—a* to further illustrate the arrangement of batteries **10**, arming switch **11** and operating switch **9** within power pack **21**. Arming switch **11** may be eliminated if desired, or alternately, external operation of switch **11** can be provided through use of a rotary switch nob accessible from end plate **17** of FIG. 3*a*. A solid-state relay may be substituted for operating switch **9** when it is desireable to activate release device **1** from an external control source **13**, which may be an acoustic receiver or manual control station connected by electric cable to device **1**. The command signal to operate device **1** is fed from control source **13** and enters device **1** through electrical feed-through **16** into solid-state relay **9**, as a gating impulse that causes relay **9** to conduct current between its anode and cathode terminals. Alternately, a mercury type tilt switch (not illustrated) may be used in place of relay **9** to serve as an attitude sensor when it is desired that device **1** operate automatically by change in its attitude, such as may be caused by the slackening of a cable in a moored array or by the sudden tumbling of another underwater device of which device **1** is an integral part. External control source **13** is not required either for manual operation of device **1**, such as the operation of switch **11** by a diver, or for automatic operation by a tilt sensor, such as a mercury switch used for operating switch **9**.

In operation, the apparatus identified as device **1** will be transported to the point of use with link **8** installed and energy source **10** fully charged, except when capacitors are used for energy source **10** it is possible to accomplish charging in situ prior to operation of device **1**. Provision can be included for insertion of a special test plug in place of switch **11** to permit field testing the condition of energy source **10** and for recharging either when using batteries or capacitors. Arming switch **11** is retained in the open position to insure that device **1** cannot operate prior to being installed. After device **1**

is connected to the mooring system or other ocean equipment and is ready to be lowered to depth, device **1** can be armed by closing switch **11**. Device **1** can also be made part of an acoustic receiver or incorporated as an integral part of other types of ocean equipment, such as lift recovery devices, wherein the release of a cable or lever is required to initiate operation or deployment at depth.

In the mooring line application, illustrated in FIG. **1**, acoustic receiver **3** becomes control source **13** and is connected to device **1** by means of electric cable (not shown) entering device **1** through feed-through **16**. Surface ship **7** transmits a command signal by acoustic means to acoustic receiver **3** which contains its own power for operation. Acoustic receiver **3** then feeds a small electric pulse (about 10 milliamperes) to device **1** through the connecting electric cable. The control pulse enter the gating circuit of relay **9**, as depicted by FIG. **2**. Relay **9** then permits current to flow from energy source **10** through switch **11** and fusible link **8** because a conductive path, offering low-impedance, is immediately established between its anode and cathode elements. Fusible link **8** is designed to weaken and fuse rapidly when subjected to a pulse current of about **10** amperes peak. Link **8** then releases lever arm **25** which initiates operation of rotary actuator **26** to release pin **36**.

An alternate method of control for operating device **1** can be obtained by omitting acoustic receiver **3** and extending a two-wire electrical cable from device **1** to surface ship **7** control station. Actuation of device **1** can then be accomplished by wire transmission of a small electric pulse from surface ship **7** control to device **1** and into the gating circuit of switch/relay **9**. Other methods for remote control operation of device **1** are readily obtained by substitution of conventional switching devices in place of acoustic receiver **3**, as for example, a timer switch or pressure switch in combination with a source d-c potential to send a control pulse to the gating circuit of relay **9**.

Still another method of control for operating device **1** can be obtained from the same basic device **1** simply by using a mercury tilt type switch in place of relay **9**. Such a mercury switch has only an anode-cathode circuit and does not require a gating input or an external control cable. The mercury switch can be selected to be normally open when held in one orientation, such as vertical. When tilted from vertical in any direction by a specified spherical angle of tilt, preferably at least 90°, the mercury will bridge the switch terminals and close the circuit. Small mercury switches, as currently available, have both low impedance and ample current capacity for repeated use of the kind required for device **1**. Also, provision can be made to prevent agitation of the mercury, during normal use, from causing accidental switch closure.

As will be apparent to those skilled in the art in the light of the foregoing disclosure, many modifications, alterations and substitutions are possible in the practice of this invention without departing from the spirit or scope thereof.

I claim:

1. A release mechanism, the combination comprising:

releasable coupling means including a relatively fixed member and a releasable member releasably coupled together with force multiplying means;

actuator means rotatable between an armed position for engaging and holding said releasable member in its coupling position, and a disarmed position for uncoupling said releasable member;

biasing means urging said actuator means from its armed to its disarmed position;

locking means for engaging and retaining said actuator means in its armed position consisting of a fusible link which, in response to command, is thermally fused by electric current means, thereby releasing said actuator means for rotation by said biasing means to its disarmed position;

electrical energy means to supply said electric current means for melting said fusible link;

communicating means for connecting said electrical energy means with said fusible link, including manual arming switch and operating switch means responsive to command.

2. In a release mechanism, the combination in accordance with claim 1, and said operating switch means further including a relay, such as a silicon controlled rectifier, responsive to command for connecting said

electrical energy means with said fusible link.

3. In a release mechanism, the combination in accordance with claim 1, and said operating switch means further including a sensor, such as a pressure sensor to sense depth or a mercury switch to sense a change in attitude, an acoustic receiver, a timing device or direct wire to control the closing of said operating switch means.

4. In a release mechanism, the combination in accordance with claim 2, and said operating switch means further including a sensor, such as a pressure sensor to sense depth or a mercury switch to sense a change in attitude, an acoustic receiver, a timing device or direct wire to operate said relay.

5. A release mechanism, the combination in accordance with claim 1, wherein the improvement comprises the substitution of a test plug for said arming switch to provide means for monitoring the condition of said electrical energy means or a source of new energy.

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