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R. A. BECKER

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PHOTOELECTRIC INFLUENCE DETECTOR AND ARMING DEVICE FOR TORPEDOES

Filed May 12, 1950

3 Sheets-Sheet 1

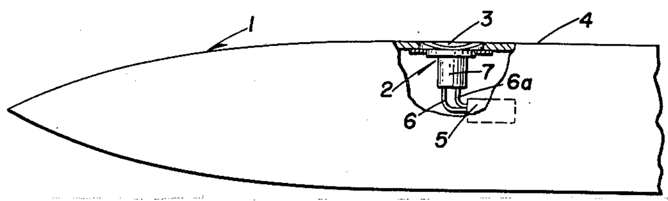

FIG. 1

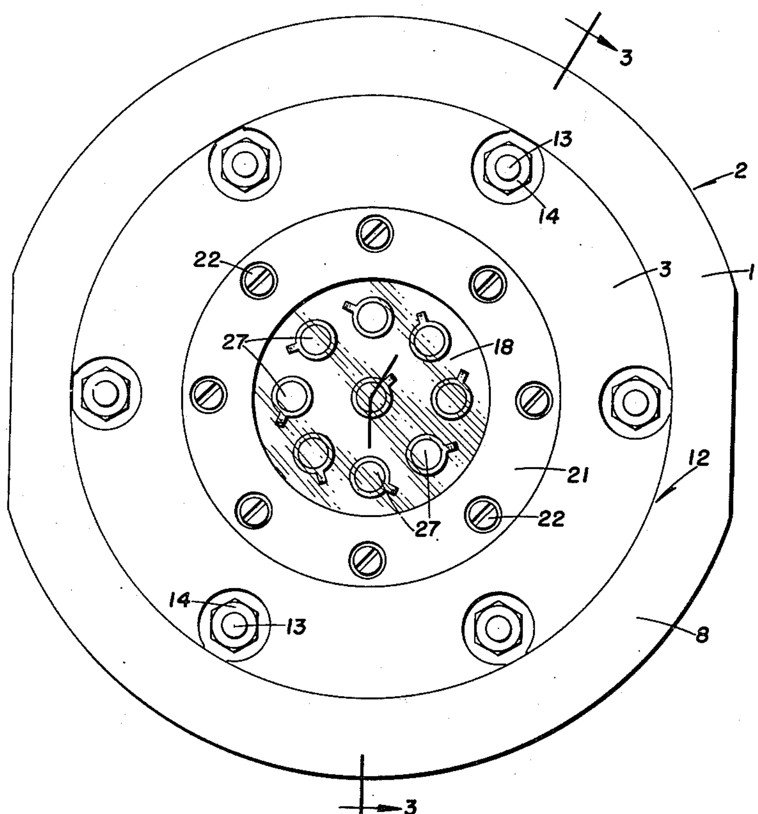

FIG. 2

INVENTOR.
ROBERT A. BECKER
BY G. D. O'Brien
ATTORNEY

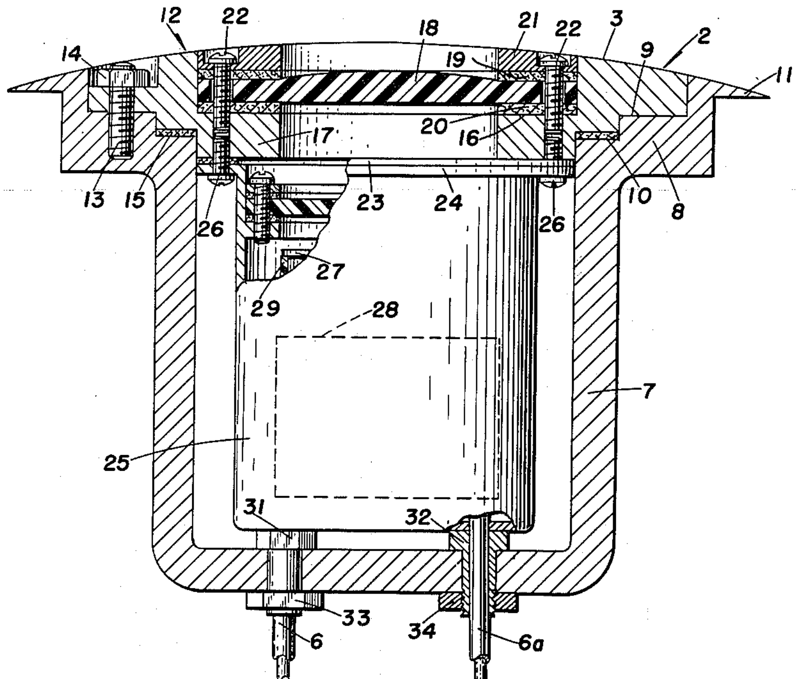

FIG. 3

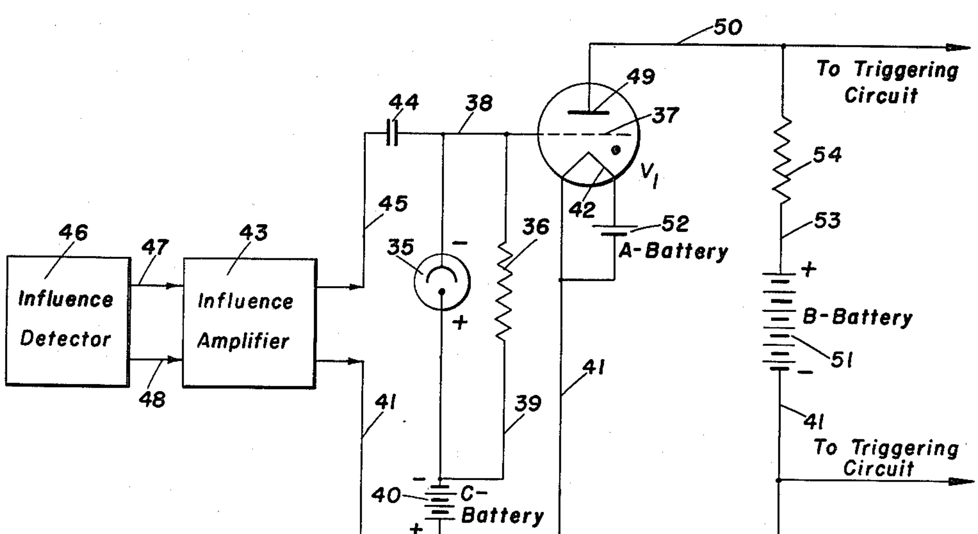

FIG. 4

INVENTOR.
ROBERT A. BECKER
BY R. D. O'Brien
ATTORNEY

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FIG. 5

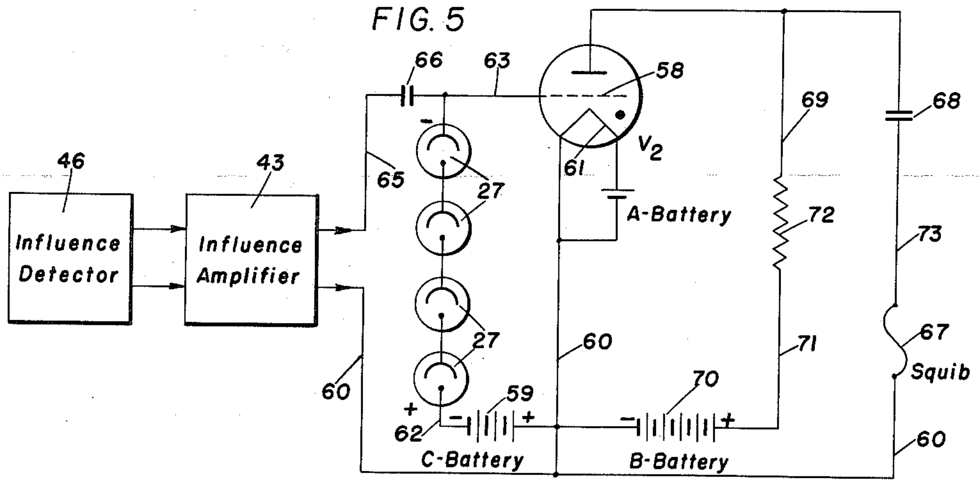
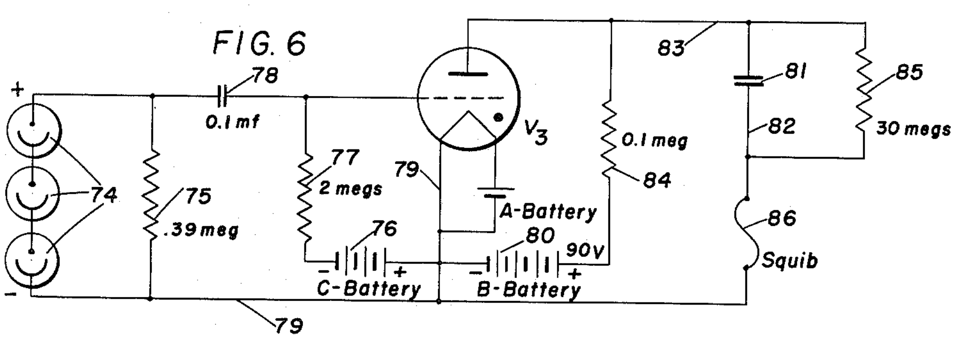


FIG. 6



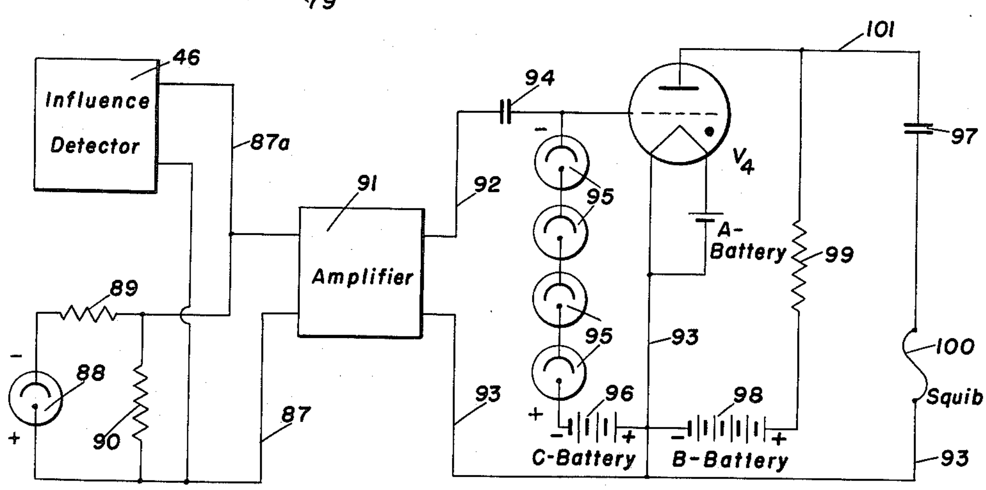


FIG. 7

INVENTOR.
ROBERT A. BECKER
BY E. D. O'Brien
ATTORNEY

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PHOTOELECTRIC INFLUENCE DETECTOR AND ARMING DEVICE FOR TORPEDOES

Robert A. Becker, Urbana, Ill., assignor to the United States of America as represented by the Secretary of the Navy

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6 Claims. (Cl. 102—70.2)

The present invention relates broadly to exploding means for aerial and submarine torpedoes, mines and similar devices, and more specifically to exploding means including combined photoelectric and magnetic control devices.

Still more specifically it relates to means wherein photo-voltaic cells constitute the effective control means during daylight hours, and magnetic influence devices assume the control function in periods of darkness, a particular feature being that these controls may be so arranged that the explosive device becomes insensitive to countermeasures intended to destroy it, as by causing premature explosion, this desensitizing being accomplished by causing the photo-electric control to prevent positively any operation of the magnetic exploder, except when the explosive device is within the shadow of its intended target. Thus the photosensitive device is capable of performing two distinct acts, which in one sense are opposite, namely, it can initiate the explosion under certain conditions, and under other conditions can also desensitize the explosive device, to prevent such explosion.

It is not new to employ a photoelectric cell, together with appropriate circuitry, to initiate the explosion of a projectile, but while early forms of photoelectric detonators, utilizing either vacuum photoelectric cells or photovoltaic cells offered the advantage of simplicity of design, they were not reliable because of the probability of premature explosion when a torpedo carrying such mechanism broaches. A further disadvantage of such photoelectric exploders is that obivously they can be effective only during the daylight hours, and therefore it is necessary to combine with such photoelectric exploders other exploders not dependent on light, if full effectiveness is to be provided. Moreover, in torpedo exploding mechanisms of the types heretofore commonly used, no fully effective means appears to have been provided for rendering the torpedo unresponsive to influence countermeasures, countermining and/or broaching.

An important object of the present invention, therefore, is to provide a photoelectric torpedo exploding device for use with submarine and aerial torpedoes, which is particularly designed for use in conjunction with an influence exploder mechanism, and which will, during daylight periods, desensitize said exploder mechanism, to prevent premature detonation by influence countermeasures or other causes.

Another object of the invention is to provide a torpedo exploder including a photoelectric detector which, during daylight periods, will cause operation of the exploder mechanism when the torpedo is beneath a vessel, whether or not said vessel has been degaussed and regardless of the material of which the vessel is constructed.

A further object of the invention is to provide a mechanism for the purpose set forth which will in no way interfere with the successful independent operation of another or other forms of influence exploders with which it may be associated or used.

Other objects and many of the attendant advantages of this invention will be appreciated readily as the same becomes understood by reference to the following detailed description, when considered in connection with the accompanying drawings, wherein:

FIG. 1 is a fragmentary side elevation of a torpedo, with a portion cut away to show how the present invention may be applied;

FIG. 2 is the plan of a photovoltaic cell unit and its mounting means, forming part of the invention;

FIG. 3 is a section through said unit and mounting means, in the planes 3—3 of FIG. 2;

FIG. 4 is a diagram showing a photoelectric desensitizer circuit for use with an influence exploder in accordance with the invention;

FIG. 5 is a diagram of a modified desensitizer circuit that may be substituted;

FIG. 6 is a diagram of a photoelectric triggering circuit according to the invention; and

FIG. 7 is a diagram showing the invention employing both a photoelectric desensitizer and a photoelectric triggering circuit.

While the invention relates primarily to the electrical features and circuits designed to accomplish the desired objects, it is helpful first to disclose certain structural details that may be used. Referring first to FIG. 1, there is shown a torpedo 1 having a photoelectric unit 2 mounted therein, preferably in such way that said unit is at the top of the torpedo when the latter is in normal operation, and with the upper surface 3 of said unit flush with the outer surface 4 of the torpedo. An influence unit 5 is also located within said torpedo, and is connected to the photoelectric unit by suitable electrical cables 6 and *6a*.

FGS. 2 and 3 show structural details of the photoelectric unit 2. Said unit comprises a cup 7 having a flange 8 at its outer or upper end. This flange has therein an outer recess defined by a shoulder 9 and an inner recess with a shoulder 10 at a somewhat deeper level. The flange 8 also tapers to a "feather-edge" at 11, to form the continuation of outer surfaces 3 and 4, already mentioned.

An annular supporting member or ring 12 fits within the flange 8, to which it is secured by threaded studs 13 and nuts 14, as shown. A gasket 15 seated on shoulder 10 serves to provide a watertight joint when ring 12 is drawn up against shoulder 9 by the said nuts 14. Ring 12 has a shoulder at 16 and a depending portion 17 extending into the bore of the cup 7.

A lens 18, preferably made of a transparent, non-brittle plastic, for example, Lucite or similar material, is seated within the ring 12, with gaskets 19 and 20 above and below it and is held in place by an outer ring 21 and screws 22. A flanged cup 25 is held to the bottom of ring 12 by screws 26, a sealing gasket 23 being clamped between its flange 24 and the lower surface of ring 12.

Within the cup 25 are located a set of photoelectric cells 27 and an amplifier unit 28. The wires or cables 6, *6a* extend through the bottom of cup 25 and the bottom of cup 7. The photoelectric cells are preferably mounted in a disk 29 made of a material such as polyethylene, Lucite, etc. having suitable insulating properties. This disk may be secured to the amplifier unit 28, whose circuit details are discussed hereinafter. Bushings 31 and 32 with nuts 33 and 34 may be provided to serve as spacers between cups 7 and 25 and to provide water-tight joints around the cables 6 and *6a*. As shown in FIG. 2, eight photoelectric cells 27, here of the photovoltaic type are arranged in a circle, with a single similar cell at its center, for purposes that are described later.

It will be understood that while the fronts of all the casings are shaped to form a continuation of the outer surface of the torpedo, so that its symmetry will not be destroyed, the lens 18 however will lie somewhat below said surface, to protect it from injury.

In FIG. 4 there is illustrated diagrammatically a circuit which makes use of a characteristic of the selenium type of photovoltaic cell, namely that exposure to light will cause two effects to occur simultaneously: first, an electromotive force is produced, second, the impedance of the cell drops.

The cell 35 is shown connected in parallel with the grid resistor 36 through the conductors 38 and 39 and with its terminals so connected that the one leading directly to the grid 37 of tube V_1 becomes more highly negative when light strikes the cell. Conductor 39 connects the remaining terminals of cell 35 and resistor 36 to the cathode 42 through the bias battery 40 and conductor 41. The electronic tube V_1 may be of either the gaseous or high vacuum type, and is here shown as a triode. It will also be understood that while for illustrative purposes only a single photovoltaic cell 35 is indicated, a number of such cells connected in series may be used.

An influence amplifier 43 which receives its input from a magnetic influence detector 46 through conductors 47 and 48, is also shown connected between the grid 37 and cathode 42 through grid capacitor 44, by conductors 41, 38 and 45. With these circuit connections at high light levels the decreased impedance of cell 35 will shunt the grid resistor 36, and/or the photoelectric current passing through said grid resistor will shift the bias of the grid sufficiently to render tube V_1 temporarily incapable of responding to the amplified output signals received from the influence amplifier 43.

The output of tube V_1 is delivered by its anode 49 through conductor 50 to a suitable triggering circuit, with return conductor 41. The negative terminal of the B-battery 51 is connected to cathode 42, energized by the A-battery 52, while the positive terminal of said B-battery is connected to anode 49 through conductor 53, resistor 54 and conductor 50.

A circuit which is perhaps more efficient than the one just described is shown in FIG. 5. In this form the desired number of photovoltaic cells 27, connected in series as shown, constitutes the grid leak of the tube V_2, here shown as a thyratron. This thyratron is prevented from firing by the existence of a sufficiently negative bias on its grid 58, which in turn is provided by several conditions acting simultaneously. It will be seen that the bias source 59 has its negative terminal connected to the positive terminal of the series of photovoltaic cells 27 by the conductor 62, said cells 27 being thus connected in series with the bias source 59 and with such polarity that they increase the negative bias of the grid 58. The voltage output of photoelectric cells 27 increases with illumination, and thus even from this cause alone the negative bias of the grid 58 will increase.

In addition to the increase of photovoltaic voltage, the impedance of the cells decreases, and since this impedance, originally relatively high, may become very small under exposure to light, the high impedance output of the influence amplifier 43 fed to grid 58 through conductors 63 and 65 and capacitor 66, and to cathode 61 through conductor 60, will be practically short circuited by the relatively low impedance of photoelectric cells 27 and battery 59, so that the influence amplifier cannot cause the thyratron V_2 to fire. This double protection is assured, namely by the increased negative bias, and by the decreased amplifier output. For completeness, it may be stated that 67 represents the squib or similar device which is fired by the discharge of capacitor 68 through the anode-cathode circuit of the thyratron V_2 when the opposing potential of grid 58 drops sufficiently to permit sudden discharge of capacitor 68, to cause firing of the squib. The battery 70 will charge the capacitor 68 through conductors 60, 69, 71 and 73 and resistor 72 and squib 67 in the usual way. The charging current is kept small by the anode load resistor 72 however, and cannot appreciably heat the squib.

While the use of photovoltaic cells for desensitizing has been disclosed in FIGS. 4 and 5, what may be called an opposite function of such cells will now be described

in connection with FIG. 6, which shows how such cells may be used to trigger the thyratron.

Here 74 represents a suitable number of such cells connected in series. In one instance 23 were used, making available a photoelectric potential change of about 5 volts upon illumination, a value which has been found satisfactory in actual operation. A resistor 75, of a magnitude best determined by trial, and which in the present instance was established as .39 magohms, is connected across the cells 74. The purpose of this resistor is to take advantage of the resistance change of the cells 74 as a function of illumination. If the resistor 75 were absent, the bias change would be limited to the actual photoelectric voltage, but since there is a closed circuit through the cells and the resistor 75, a current will flow therein, producing an IR drop. When the voltage of the cells rises, their internal resistance decreases concurrently so that while the current rises the said IR drop in 75 rises proportionally, but the IR drop in the cells due to their internal resistance R rises at a lower rate, or even drops, because R itself is decreasing. Hence the voltage change at the terminals of the cells will be larger than it would be if resistor 75 were omitted. All this presupposes, of course, that the resistance value of 75 is chosen properly.

The remainder of the circuit is not very different from the firing circuits already described, and comprises the bias source 76 connected to the grid of V_3 through resistor 77, here 2 megohms, the photovoltaic circuit being coupled to said grid through the 0.1 mfd. capacitor 78, and to the cathode through conductor 79. A pulse will thus traverse this capacitor and reach the grid upon relatively sudden illumination change of the cells 74, and this pulse in case of increased light will tend to make the grid less negative, thus permitting the thyratron to fire.

The anode circuit derives its energy from the 90 volt B-battery 80. Capacitor 81, of 1 mfd. capacity, is charged through conductors 82 and 83 and resistor 84 of 100,000 ohms, which determines its rate of charge. A leak resistor 85 of high value, say 30 megohms, is shunted across the capacitor, and acts as a delay. The discharge through the squib 86 takes place through the anode circuit of the tube V_3 when a sufficient pulse reaches its grid from the cells 74.

Passing now to FIG. 7, there is shown a circuit including both a photoelectric triggering means and a photoelectric desensitizer. This circuit may use "double" triggering means, for example a detector 46 of any influence device connected in parallel with a photoelectric detector such as the photovoltaic cell 88. Resistors 89 and 90 may be provided, if necessary, for impedance matching.

The outputs, jointly or severally, of these two triggering means 46 and 88 are fed through wires 87 and 87*a* to the input side of a suitable amplifier 91 whose output is then fed through wires 92 and 93 and capacitor 94, to the grid-cathode circuit of the thyratron V_4. It will be seen that the thyratron circuits here shown are substantially the same as shown in FIG. 5. Briefly, a series of photovoltaic cells 95 constitutes the grid leak, and 96 is the C-battery, the cells 95 acting to increase the bias when illuminated, and thus serving as a desensitizer. The firing capacitor 97 is charged by B-battery 98 through the resistor 99 and wire 101 and will discharge through the squib 100 and the anode-cathode circuit of the thyratron when a pulse, sufficiently large to reduce the grid bias to a value at which the thyratron fires, passes through the capacitor 94. A decrease in light falling on the cell 88 will cause its voltage to decrease and the grid of thyratron V_4 will be made positive by the amplified pulse from cell 88. The same decrease in illumination affects the cells 95 so as to decrease the grid bias on V_4, thereby decreasing their shunting effect and allowing the grid bias to rise above the firing point.

In the present disclosure the term "photoelectric" is to be considered broadly to define all types of apparatus wherein an electrical characteristic such as voltage, resistance, current, etc. is changed in response to light or equivalent radiation, for example, the selenium cell, the photovoltaic (self-generating) cell and the photoelectric cell, of either high vacuum or gas-filled type, to the extent that such diverse means are suitable in any specific instance. While here the photoelectric device that is perhaps most generally useful is the photovoltaic cell, because of its simplicity, as it requires no outside source of electricity and also because of its dual variation in response to radiation, namely, the generation of a voltage and the change of its resistance, yet some of the advantages of the invention may be secured even on substitution of other types of photoelectric means in certain parts thereof.

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

What is claimed is:

1. A combined photoelectric and magnetic influence exploder comprising a thermionic tube having a cathode, a grid, and an anode, photoelectric means connected between cathode and grid whereby the grid bias varies with the illumination of said means, said means being connected with such polarity that increasing illumination makes the grid correspondingly more negative, and a magnetic influence exploder also connected to said grid with polarity opposite that of said means.

2. An exploder as defined in claim 1 with an additional photoelectric means connected with the grid in opposite polarity to the first means, to act as an auxiliary exploder.

3. A torpedo having a photoelectric device associated therewith, said device being located within the torpedo adjacent its forward surface, said surface including a light-transmitting portion through which light may reach the said device from outside the torpedo, a magnetic influence exploder in the torpedo, and a voltage sensitive squib-igniter to which the said device and the exploder are connected in opposite polarity, whereby said photoelectric device prevents operation of said squib-igniter whenever the illumination of said device exceeds a predetermined value.

4. A torpedo as defined in claim 3 including also a second photoelectric apparatus connected to the squib-igniter in the same sense as the influence exploder, and capable of causing detonation of the torpedo in response to abnormal light fluctuation.

5. A fuze for a torpedo comprising a gas-filled triode having a squib and a first capacitor in series in its plate circuit, a B-battery and a limiting resistor in series with each other and in parallel with the squib and capacitor, a C-battery and a first photovoltaic means in series connected from cathode to grid of said triode and having their polarities connected to bias the grid negatively to a value above the firing value, an amplifier having its output connected across the grid and cathode of the triode through a second capacitor, a second photovoltaic means connected across the input of said amplifier in such a manner that a decrease of voltage across said second photovoltaic means causes the grid bias to become less negative, and a magnetic influence detector connected across the input of said amplifier in such a manner that the generation of a voltage therein by the presence of an object in the neighborhood causes the grid bias to become less negative, thus causing the triode to fire whereupon the capacitor discharges and ignites the squib.

6. A fuze for a torpedo comprising a thyratron having a squib and a capacitor connected in series from plate to cathode and having a plate power source also connected thereacross, a means including a photovoltaic cell connected from grid to cathode and normally biasing the grid sufficiently to prevent firing of the tube, an amplifier having its output connected from grid to cathode through a capacitor, a second photovoltaic cell and a magnetic influence detector connected in parallel with each other across the input of the amplifier in such manner that either a decrease in voltage across the second cell or the generation of a voltage in the detector causes the grid bias to become less negative, thus firing the tube, enabling the capacitor to discharge and ignite the squib.

References Cited in the file of this patent

UNITED STATES PATENTS

1,382,374	Maxim	June 21, 1921
2,060,205	Hammond	Nov. 10, 1936
2,462,118	Minkler	Feb. 22, 1949