

"TORPEDO PROVIDED WITH A SAFETY ARMING SYSTEM"

Cross-Reference to Related Applications

This Patent Application claims priority from Italian
5 Patent Application No. 102023000005646 filed on March 24,
2023, the entire disclosure of which is incorporated herein
by reference.

Technical Field

The present invention relates to a torpedo provided
10 with a safety arming system.

Background of the Invention

As is well known, torpedoes carry an **explosive charge** which
is activated by a pyrotechnic chain consisting of a total of
three explosive components:

15 **a detonator** which typically receives an activation
command from an electronic control unit on board the torpedo;

a booster explosive which is detonated by the detonator;
and

a main explosive which explodes as a result of the
20 explosion of the booster if the booster is in contact with
the main explosive.

The detonator is the most reactive and sensitive
explosive in the chain, the detonation of which would in
itself pose no danger to the torpedo and an operator given
25 the small quantity.

The booster explosive is an intermediate which is less sensitive than the detonator but whose detonation would itself cause a small amount of damage to the torpedo.

In order to prevent an accidental detonation of the main explosive, the three components are alternately physically available within the torpedo from a **safety position** in which an accidental detonator explosion does not propagate and cannot detonate the main explosive to a **weapon** position in which the three components are physically aligned along one direction and an explosion of the detonator sequentially detonates the booster and main explosive.

The movement of the three components from the safety position to the **weapon** position is accomplished by an actuator which moves a device (e.g., a carriage or a rotating carousel, etc.) and is actuated by the electronic control unit, typically an actuator with a pyrotechnic trigger is used.

The torpedo must be brought into the **weapon** position only when two conditions have been verified, the torpedo has been completely ejected from the submarine's launch tube and it has moved away from the submarine by a clearance distance.

To be precise, the standards such as STANAG 4187 mention two independent physical stimuli which can only occur as a result of firing. One of the two stimuli must ensure the clearance distance or "Equivalent Delay". (see par 6 of

STANAG)

The first condition can be verified by means of a sensor fitted with an appendage which presses on the launch tube casing when the torpedo is contained in the launch tube and
5 extends outwards from the torpedo when the torpedo has exited the launch tube. Typically, a probe pushed by a spring is used. The displacement of the appendage produces the signal which indicates the exit of the torpedo.

The torpedo distancing condition is instead accomplished by
10 arranging a main source of electrical energy (thermal battery) in the torpedo, which is only fully activated a few seconds after the torpedo has exited the launch tube; the detonator can only be activated when such an electrical energy source has been fully activated and provides a voltage
15 above a limit value.

The exit of the torpedo from the launch tube is accomplished by pushing the torpedo mechanically or by means of pressurised fluids, or by using auxiliary batteries which rotate the torpedo propellers.

20 It is clear from the above that should the main electrical source be activated immediately following the torpedo's exit, the torpedoes of a known type operating with the procedures described above would immediately move into the weapon position following the exit from the launch tube
25 itself and would be inherently dangerous.

US 2954734 illustrates a torpedo detonator.

Summary of the Invention

The object of the present invention is to make a torpedo which can be safely distanced from the submarine following
5 its exit from the launch tube and the simultaneous activation of the main power source.

The preceding object is achieved by the present invention in that it relates to a torpedo provided with a weapon safety system as envisaged in claim 1.

10 The present invention further relates to a method of the type envisaged in claim 3.

Brief Description of the Drawings

The invention will now be illustrated with reference to the attached figures illustrating a non-limiting embodiment
15 wherein:

Figure 1 illustrates a longitudinal section of the torpedo provided with a safety system made according to the present invention; and

Figure 2 illustrates a circuit of the torpedo of figure
20 1.

Description of Embodiments of the Invention

Figure 1 shows a torpedo 1 comprising a tubular cylindrical body 2 elongated along an axis H and housing in the back an electric propulsion motor 3 (e.g., an axial-flow
25 electric motor) driving a multi-bladed rear propeller 4.

However, it is clear that the electric motor may also not be with axial flow.

At the front, the body 2 is provided with an acoustic head 5 (of known type) and houses an explosive warhead 6 described later and also of known type.

The body 2 houses a power supply, e.g., a thermal battery 7 (of known type, e.g., a thermal battery which is activated following the entry of seawater), a battery or any other power supply which powers the electric propulsion motor 3 and an electronic control unit 8 which commands a torpedo mission towards a target.

The explosive warhead 6 of known type comprises three explosive components forming a pyrotechnic chain:

a **detonator** 10 which receives an **activation command** from the control unit 8;

a **booster explosive** 11 which is detonated by the detonator 10; and

a **main explosive** 12 which explodes following the explosion of the booster 11.

The three components 10, 11 and 12 are physically available within the torpedo alternately from a **safety position** in which an accidental detonation of the detonator 10 does not propagate and the explosion of the main explosive 12 cannot operate, to a **weapon** position in which the three components 10, 11 and 12 are physically aligned along one

direction and an explosion of the detonator 10 sequentially carries out the explosion of the booster 11 and the main explosive 12 (pyrotechnic chain alignment).

The movement of the three components 10, 11 and 12 from the safety position to the **weapon** position is accomplished by an actuator (of known type and not illustrated) which moves a carriage or other similar device (not illustrated) and is actuated by the control unit 8, can be an actuator with a pyrotechnic trigger or an electric motor.

The power source 7 is configured to activate immediately following the exit of the torpedo 1 from the launch tube (not illustrated) of an underwater vehicle (not illustrated) to provide the voltage required to power the electric motor 3. Immediately is intended as a few seconds after the launch.

According to the present invention, the electronic control unit 8 is configured to measure the intensity of the current I_{mot} absorbed by the electric motor 3 following the activation of the power source 7 and compare this current with a first lower current threshold $I_{\text{mot-low}}$ and a second higher current threshold $I_{\text{mot-high}}$ in order to safely perform the following control operations of the warhead 6:

a) if the intensity I_{mot} of the measured current is less than the first lower current threshold $I_{\text{mot-low}}$ the generation and/or transmission of the activation command to the detonator 10 or the arrangement of the three components in

the arming position is prevented;

- b) if the intensity I_{mot} of the measured current is greater than the second higher threshold $I_{\text{mot-high}}$ the generation and/or transmission of the activation command to the detonator 10 or the arrangement of the three components in the arming position is inhibited;
- c) if the intensity I_{mot} of the measured current is comprised between the first lower threshold $I_{\text{mot-low}}$ and the second higher threshold $I_{\text{mot-high}}$, the generation and/or transmission of the activation command to detonator 10 or the arrangement of the three components in the arming position is authorised. Typically, the first condition (a) is associated with the following anomalies of the torpedo 1:
- i) propeller 4 not properly connected (mechanical problem) - the current absorbed by the motor 3 is in fact low due to the absence of load; and
- ii) activation of the torpedo outside water - the current absorbed by the motor 3 is low due to the absence of load. Such a situation can occur if the torpedo is launched from a ship's launch tube and accidentally falls onto the ship's deck or the torpedo is accidentally activated in a test environment or laboratory; and electrically damaged propulsion system (e.g., 'damaged motor' which can be assimilated to an open circuit or high impedance load). Typically the second condition b) is

associated with the following anomaly of the torpedo 1:

- iii) motor 3 blocked following an electrical or mechanical problem
 - high current absorbed by the motor 3;
- iv) incorrect motor speed; and
- v)5 reduced motor resistance, which can be assimilated to an electrical short circuit or a load which has gone into low impedance (burnt or damaged motor).

Typically, the third condition c) is associated with the following normal operating condition of the torpedo 1:

- vii)0 advancement of the torpedo in water towards the target under the control of the electronic control unit 8 with the correct motor speed in the intended operating range.

Figure 2 schematically illustrates an electronic filter circuit 30 adapted to allow the transmission of the
15 activation command from the electronic unit 8 to the detonator 10 when the intensity I_{mot} of the measured current is comprised between the first lower current threshold $I_{\text{mot-low}}$ and the second higher threshold $I_{\text{mot-high}}$ for a predetermined time interval.

20 A possible embodiment of the circuit 30 comprises:

a first comparator 31 which has a non-inverting input (+) to which is fed a voltage proportional to the current I_{mot} absorbed by the motor 3 and an inverting input (-) which receives a reference voltage proportional to the second
25 higher threshold $I_{\text{mot-high}}$:

a second comparator 32 which has an inverting input (-) to which is fed the voltage proportional to the current I_{mot} absorbed by the motor 3 and a non-inverting input which receives a reference voltage proportional to the first lower
5 threshold $I_{\text{mot-low}}$:

a NOR logic gate 34 which receives the output of the first comparator 31 and the second comparator 32 in input;

the NOR logic gate 34 has an output connected to a filter 35 which transmits the input logic state 1 when the
10 output of the NOR logic gate 34 remains in state 1 for a predetermined time;

the output of the filter 35 controls the switching of a switch 36 which is closed to allow the transmission of the activation signal from the electronic control unit 8 to the
15 trigger of the detonator 10.

Thereby, when the first voltage is below the second threshold ($I_{\text{mot}} < I_{\text{high}}$) the output of comparator 31 goes to zero and when the voltage is above the first threshold ($I_{\text{mot}} > I_{\text{low}}$) the output of the second comparator also goes to zero. Thereby,
20 the output of the logic gate is 1. When this state persists for a predetermined time interval, the switch 36 is closed and the activation signal is transmitted from the electronic control unit 8 to the detonator 10.

In a variant not illustrated, the three components are
25 always in the activation position. In this case:

- a) if the intensity I_{mot} of the measured current is below the first lower current threshold $I_{\text{mot-low}}$, the generation and/or transmission of the activation command to the detonator (10) is prevented;
- 5b) if the intensity I_{mot} of the measured current is above the second higher current threshold $I_{\text{mot-high}}$ the generation and/or transmission of the activation command to the detonator (10) is prevented;
- c) if the intensity I_{mot} of the measured current is between the
10 first lower current threshold $I_{\text{mot-low}}$ and the second higher current threshold $I_{\text{mot-high}}$ the generation and/or transmission of the activation command to the detonator (10) is allowed.

Claims

1.- A torpedo (1) comprising a cylindrical tubular casing (2) housing at the rear an electric propulsion motor (3) that drives a propulsive propeller (4); the casing houses
5 an explosive warhead (6), a power source (7) that powers the electric propulsion motor (3) and an electronic control unit (8);

the explosive warhead (6) comprises three explosive components:

10 **a detonator** (10) that receives an activation command from the control unit (8);

an explosive booster (11) that is detonated by the detonator (10); and

15 **a main explosive** (12) that detonates following the explosion of the booster (11);

 the three explosive components (10, 11, and 12) are physically available within the torpedo from a **safety position** in which any accidental explosion of the detonator (10) does not propagate and cannot operate the explosion of
20 the main explosive (12) to an **arming** position in which the three explosive components (10, 11, and 12) are physically aligned along one direction and an explosion of the detonator (10) sequentially triggers the explosion of the booster (11) and the main explosive (12);

25 the power source (7) is configured to activate

immediately following the exit of the torpedo (1) from the launch tube of an underwater means to provide the voltage necessary to power the electric motor (3), characterized in that it comprises means configured to
5 compare the intensity of the current I_{mot} absorbed by the electric motor (3) following activation of the power source (7) with a first lower current threshold $I_{\text{mot-low}}$ and a second higher current threshold $I_{\text{mot-high}}$ in order to safely perform the following control operations of the warhead (6):

- 10a) if the intensity I_{mot} of the measured current is below the first lower current threshold $I_{\text{mot-low}}$ the generation and/or transmission of the activation command to the detonator (10) or the arrangement of the three components in the arming position is prevented;
- 15b) b) if the intensity I_{mot} of the measured current is above the second higher current threshold $I_{\text{mot-high}}$ the generation and/or transmission of the activation command to the detonator (10) or the arrangement of the three components in the arming position is prevented;
- 20c) if the intensity I_{mot} of the measured current is between the first lower current threshold $I_{\text{mot-low}}$ and the second higher current threshold $I_{\text{mot-high}}$ the generation and/or transmission of the activation command to the detonator (10) or the arrangement of the three components in the arming position
25 is allowed.

2.- The torpedo (1) comprising a cylindrical tubular casing (2) housing at the rear an electric propulsion motor (3) that drives a propulsive propeller (4); the casing houses an explosive warhead (6), a power source (7) that powers the electric propulsion motor (3) and an electronic control unit (8);

the explosive warhead (6) comprises three explosive components:

a **detonator** (10) that receives an activation command from the control unit (8);

an **explosive** booster (11) that is detonated by the detonator (10); and

a **main explosive** (12) that detonates following the explosion of the booster (11);

the three explosive components (10, 11, and 12) are arranged in an **arming** position in which the three explosive components (10, 11, and 12) are physically aligned along one direction, and an explosion of the detonator (10) sequentially triggers the explosion of the booster (11) and the main explosive (12);

the power source (7) is configured to activate immediately following the exit of the torpedo (1) from the launch tube of an underwater means to provide the necessary voltage to power the electric motor (3), characterized in that it comprises means configured to

compare the intensity of the current I_{mot} absorbed by the electric motor (3) following the activation of the power source (7) with a first lower current threshold $I_{\text{mot-low}}$ and a second higher current threshold $I_{\text{mot-high}}$ in order to safely
5 perform the following control operations of the warhead (6):

- a) if the intensity I_{mot} of the measured current is below the first lower current threshold $I_{\text{mot-low}}$, the generation and/or transmission of the activation command to the detonator (10) is prevented;
 - 10b) if the intensity I_{mot} of the measured current is above the second higher current threshold $I_{\text{mot-high}}$ the generation and/or transmission of the activation command to the detonator (10) is prevented;
 - c) if the intensity I_{mot} of the measured current is between the
15 first lower current threshold $I_{\text{mot-low}}$ and the second higher current threshold $I_{\text{mot-high}}$ the generation and/or transmission of the activation command to the detonator (10) is allowed.
- 3.** - The torpedo according to claim 1 or 2, wherein filtering means (30) are provided designed to enable transmission of
20 the activation command from the electronic unit to the detonator (10) when the intensity I_{mot} of the measured current is between the first lower current threshold $I_{\text{mot-low}}$ and the second higher current threshold $I_{\text{mot-high}}$ for a predetermined time interval.

25 **4.-** A method for controlling a torpedo (1) wherein a

cylindrical tubular casing (2) houses at the rear an electric propulsion motor (3) that drives a propulsive propeller (4); the casing houses an explosive warhead (6), a power source (7) that powers the electric propulsion motor (3) and an
5 electronic control unit (8);

the explosive warhead (6) comprises three explosive components:

a **detonator** (10) that receives an activation command from the control unit (8);

10 an **explosive** booster (11) that is detonated by the detonator (10); and

a **main explosive** (12) that detonates following the explosion of the booster (11);

the method comprises the alternative steps of:

15 arranging the three explosive components (10, 11, and 12) inside the torpedo in a **safety position** in which any accidental explosion of the detonator (10) does not propagate and cannot operate the explosion of the main explosive (12); and

20 arranging the three explosive components (10, 11, and 12) in an **arming** position in which the three components are physically aligned along one direction and an explosion of the detonator (10) sequentially triggers the explosion of the booster (11) and the main explosive (12);

25 the method further comprising the steps of:

- activating the power source (7) following the exit of the torpedo (1) from the launch tube of an underwater means to provide the necessary voltage to power the electric motor (3),
 - 5- comparing the intensity of the current I_{mot} absorbed by the electric motor (3) following the activation of the thermal stack (7) with a first lower current threshold $I_{\text{mot-low}}$ and a second higher current threshold $I_{\text{mot-high}}$ in order to safely perform the following control operations of the warhead (6):
 - 10a) if the intensity I_{mot} of the measured current is below the first lower current threshold $I_{\text{mot-low}}$ prevent the generation and/or transmission of the activation command to the detonator (10) or the arrangement of the three components in the arming position;
 - 15b) if the intensity I_{mot} of the measured current is above the second higher current threshold $I_{\text{mot-high}}$ prevent the generation and/or transmission of the activation command to the detonator (10) or the arrangement of the three components in the arming position;
 - 20c) if the intensity I_{mot} of the measured current is between the first lower current threshold $I_{\text{mot-low}}$ and the second higher current threshold $I_{\text{mot-high}}$ allow the generation and/or transmission of the activation command to the detonator (10) or the arrangement of the three components in the arming
- 25 position.

5.- The method for controlling a torpedo (1) in which a cylindrical tubular casing (2) houses at the rear an electric propulsion motor (3) that drives a propulsive propeller (4); the casing houses an explosive warhead (6),
5 a power source (7) that powers the electric propulsion motor (3) and an electronic control unit (8);

the explosive warhead (6) comprises three explosive components:

a **detonator** (10) that receives an activation command
10 from the control unit (8);

an **explosive** booster (11) that is detonated by the detonator (10); and

a **main explosive** (12) that detonates following the explosion of the booster (11);

15 the method comprises the alternative steps of:

the method comprising the steps of:

- activating the power source (7) following the exit of the torpedo (1) from the launch tube of an underwater means to provide the voltage necessary to power the electric motor
20 (3),
- comparing the intensity of the current I_{mot} absorbed by the electric motor (3) following the activation of the thermal stack (7) with a first lower current threshold $I_{\text{mot-low}}$ and a second higher current threshold $I_{\text{mot-high}}$ in order to safely
25 perform the following control operations of the warhead (6):

- d) if the intensity I_{mot} of the measured current is below the first lower current threshold $I_{\text{mot-low}}$ prevent the generation and/or transmission of the activation command to the detonator (10);
- 5e) if the intensity I_{mot} of the measured current is above the second higher current threshold $I_{\text{mot-high}}$ prevent the generation and/or transmission of the activation command to the detonator (10);
- f) if the intensity I_{mot} of the measured current is between the
10 first lower current threshold $I_{\text{mot-low}}$ and the second higher current threshold $I_{\text{mot-high}}$ allow the generation and/or transmission of the activation command to the detonator (10).
- 6.- The method according to claim 4 or 5 wherein a filtering
15 step is provided designed to allow transmission of the activation command from the electronic unit (8) to the detonator (10) when the intensity I_{mot} of the measured current is between the first lower current threshold $I_{\text{mot-low}}$ and the second higher current threshold $I_{\text{mot-high}}$ for a predetermined time interval.