July 5, 1960 R. C. WOLFE 2,943,569

ORDNANCE EXPLODING MECHANISM

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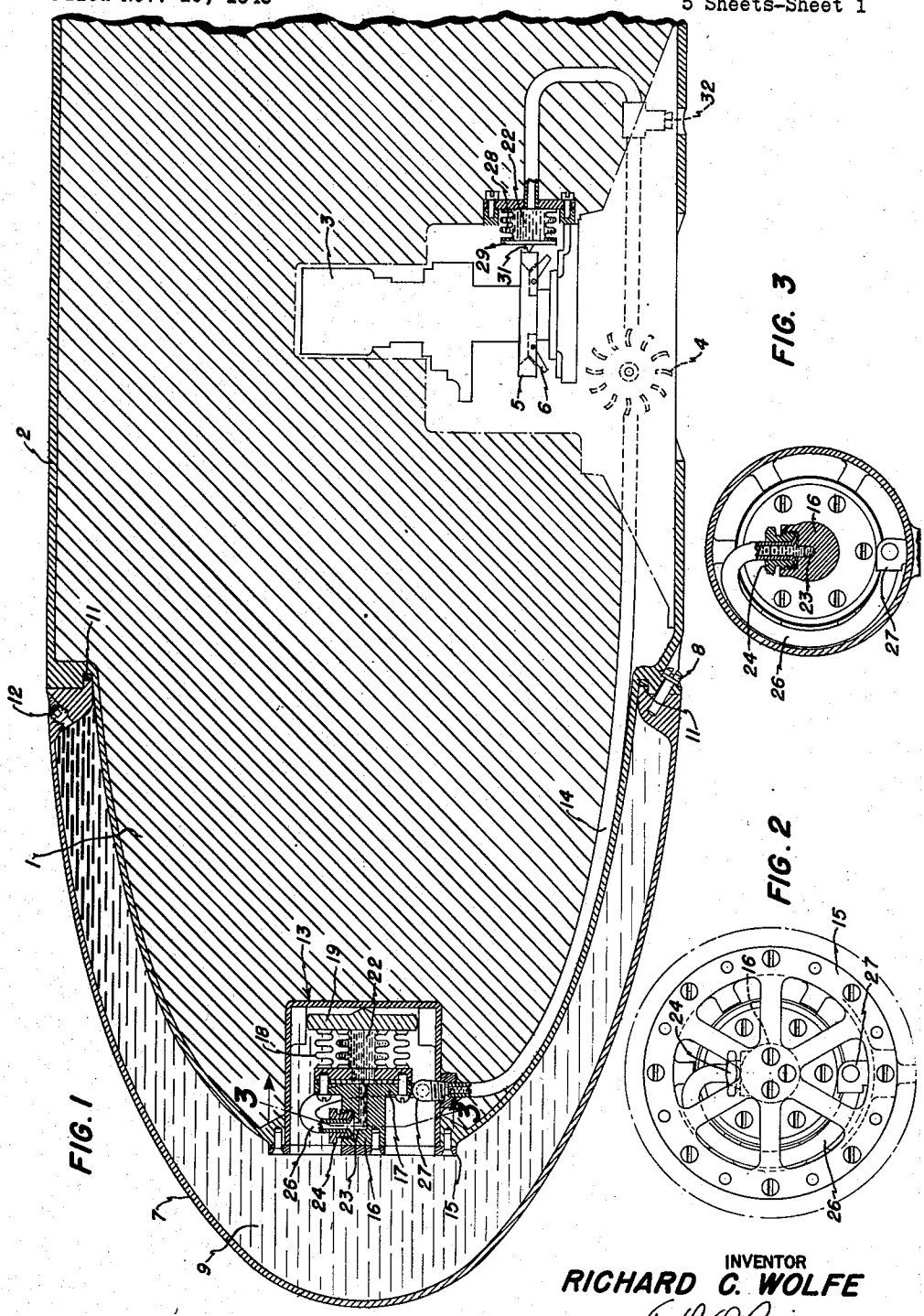


FIG. 1

FIG. 3

FIG. 2

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ORDNANCE EXPLODING MECHANISM

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FIG. 5

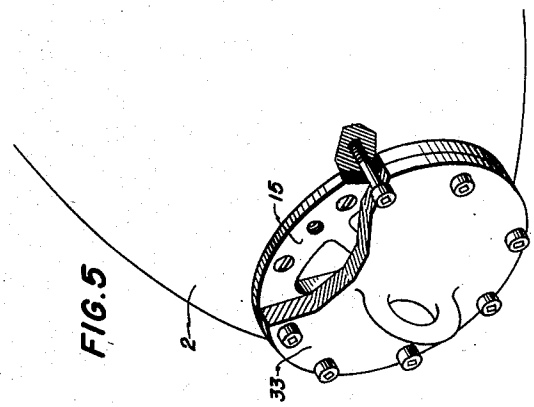
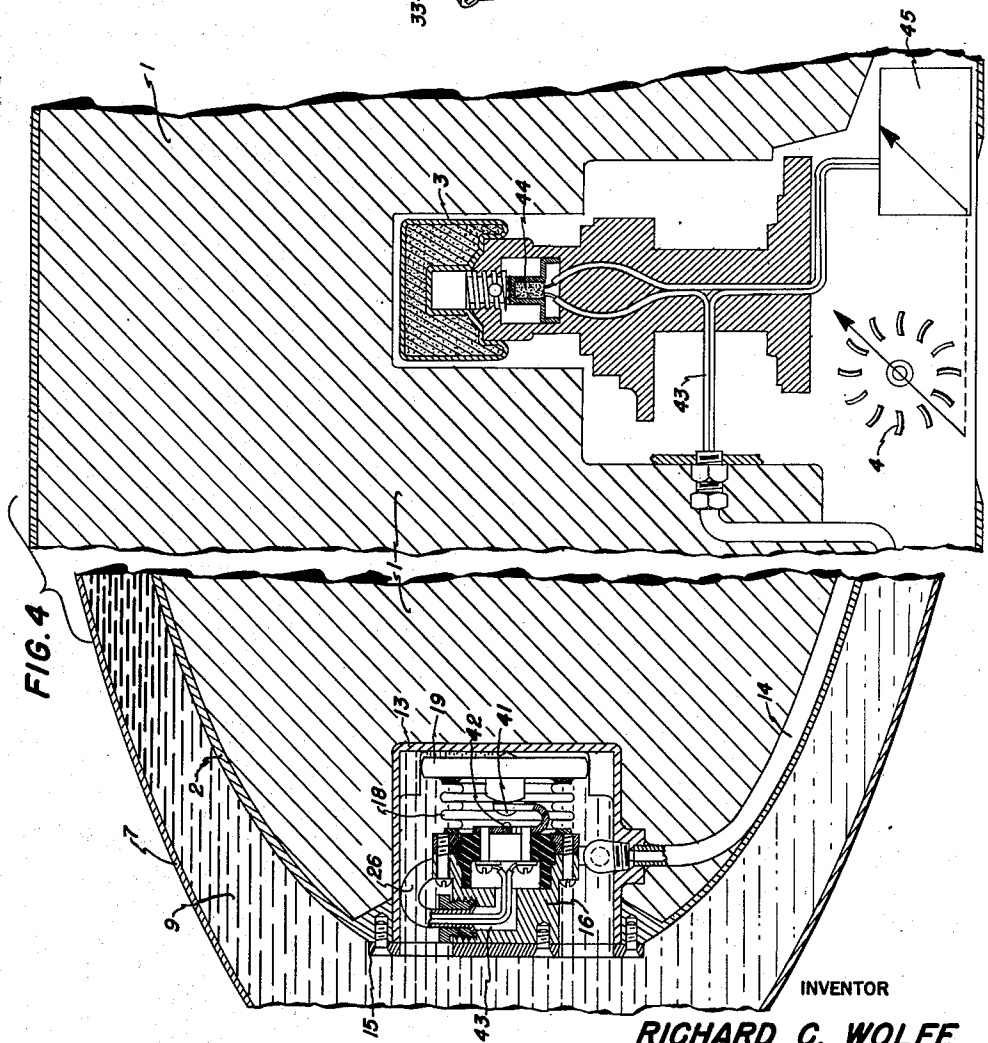


FIG. 4



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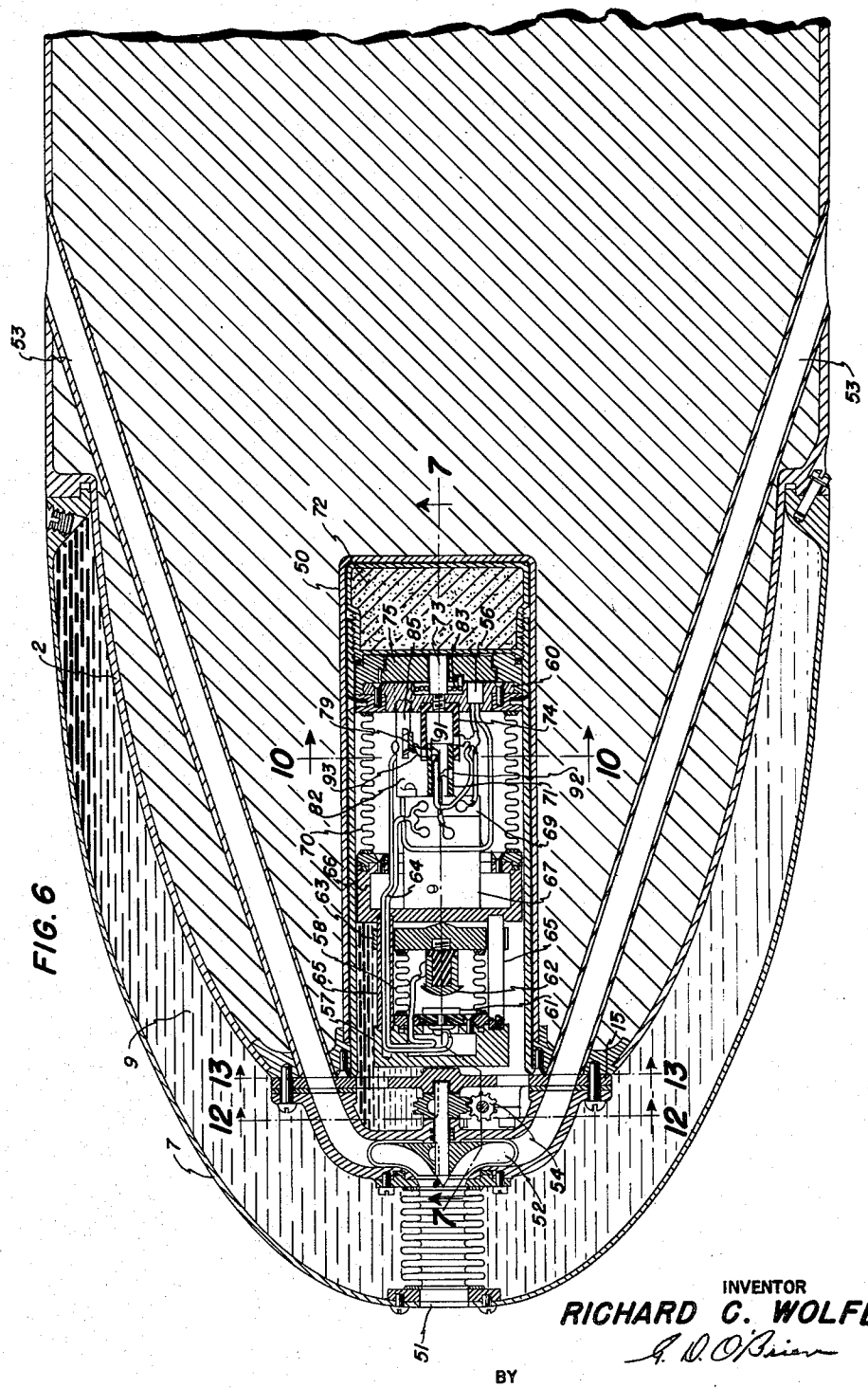


FIG. 6

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FIG. 9

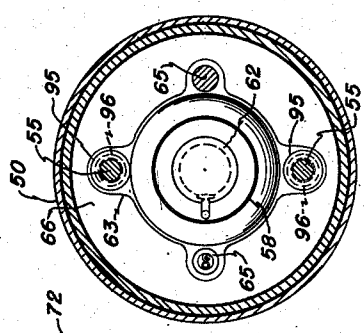


FIG. 7

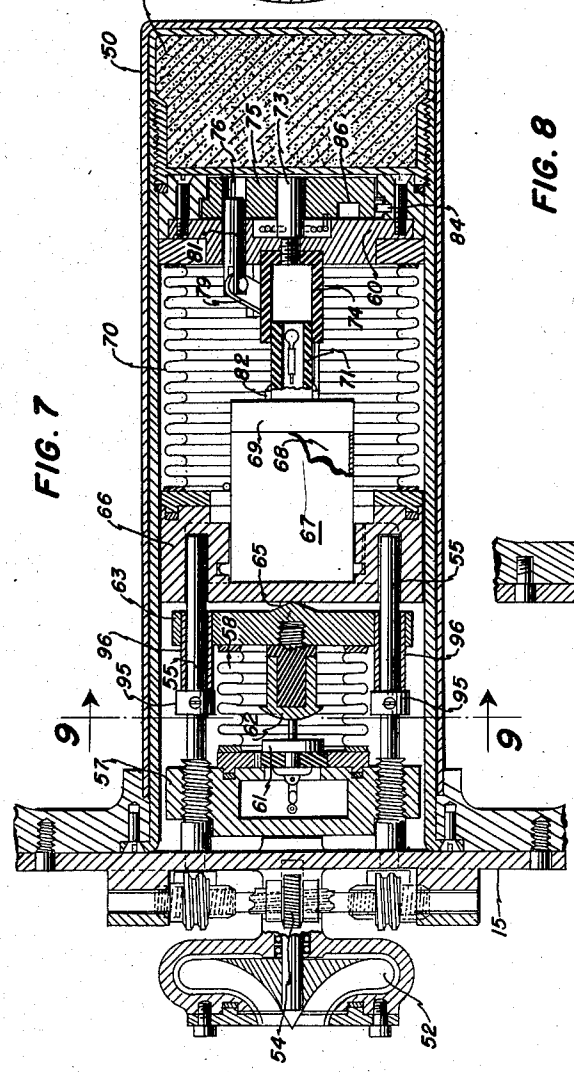


FIG. 8

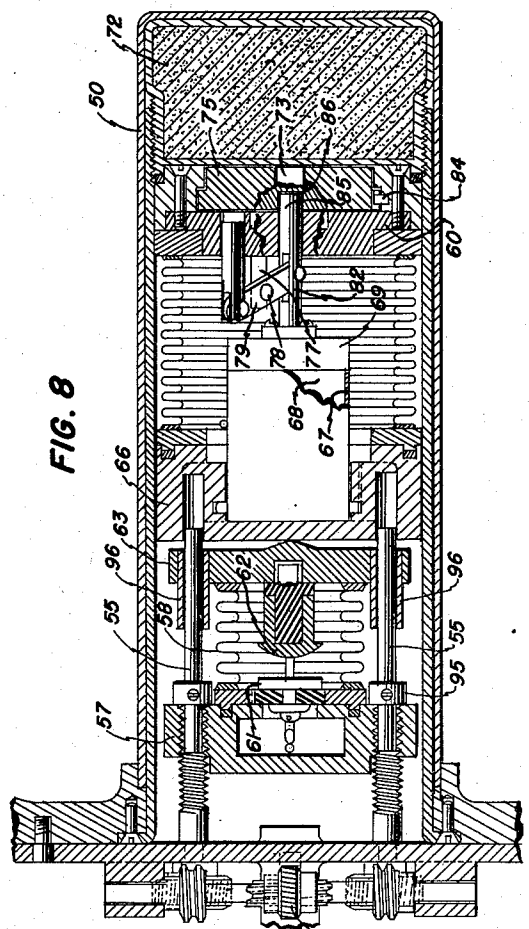
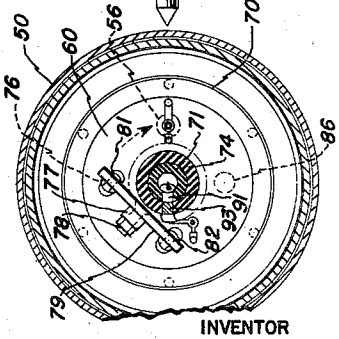


FIG. 10



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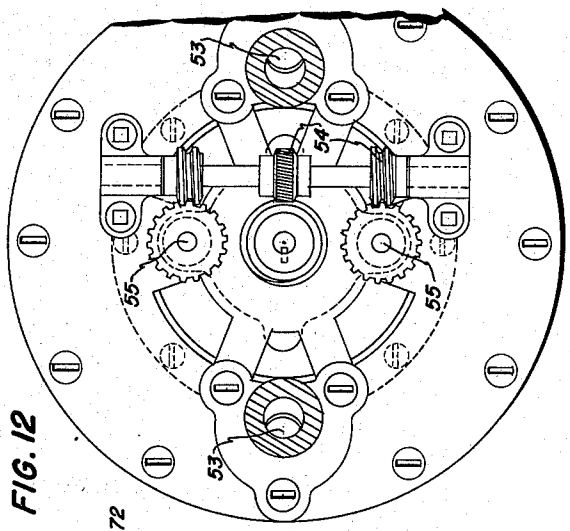


FIG. 12

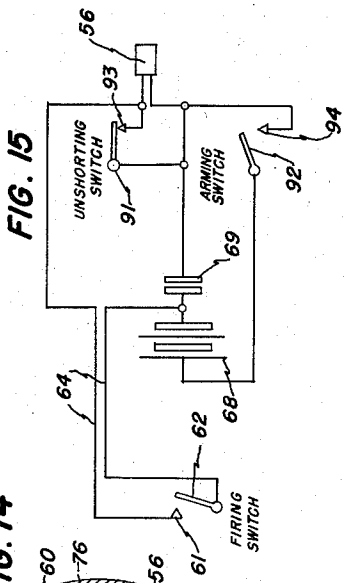


FIG. 15

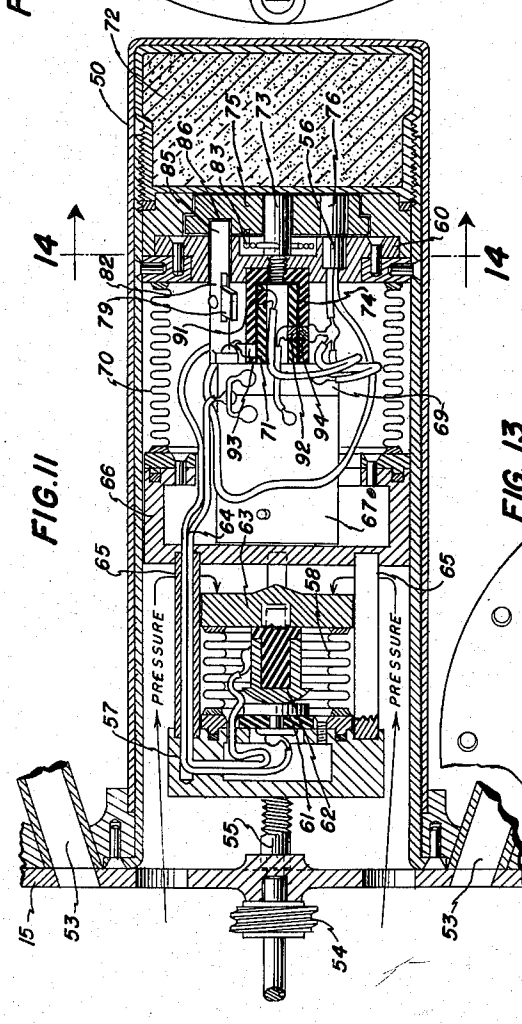


FIG. 11

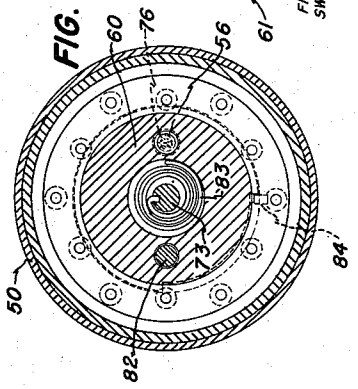


FIG. 14

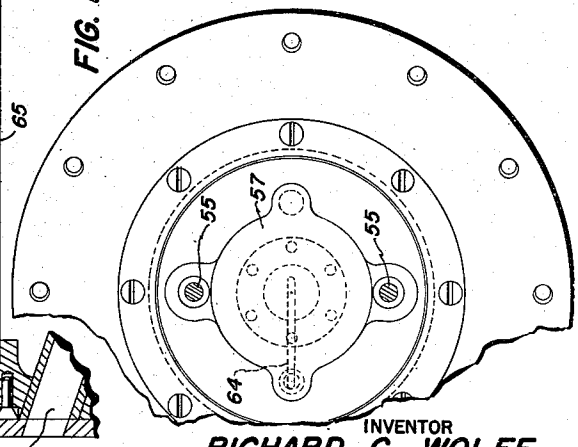


FIG. 13

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United States Patent Office

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ORDNANCE EXPLODING MECHANISM

Richard C. Wolfe, United States Navy, Los Angeles, Calif., assignor to the United States of America as represented by the Secretary of the Navy

Filed Nov. 19, 1945, Ser. No. 629,686

15 Claims. (Cl. 102—16)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to torpedoes and more particularly to a device for exploding the warheads of torpedoes.

The warhead of a conventional torpedo contains a device called an exploder that is designed to fire the main charge, when the torpedo strikes the target. Upon impact an element in the exploder is displaced by inertia or directly by contact with the target and releases a firing pin or closes a switch to fire a detonator, which in turn detonates a booster to explode the main charge. To minimize risk and to prevent explosion of the warhead while the projectile is still in the vicinity of the launching vessel, the detonator is kept in a safety chamber. An impeller wheel at the exterior of the exploder is rotated by the sea water during travel, and the motion of this wheel is mechanically translated to a mechanism for withdrawing the detonator from the safety chamber or for removing a barrier between the detonator and the booster. This operation puts the detonator in a position where ignition thereof will react on the booster and thence on the main charge. The process of withdrawing the detonator charge from its safety chamber, or the safety barrier from between the detonator and the booster is called arming the exploder.

The conventional inertia exploder thus described must be sufficiently sensitive to operate at all angles and velocities of impact. It must also be sufficiently sensitive to operate on a lightly-constructed or "soft" target. This sensitiveness, unfortunately, may have serious repercussions. As is well known, a torpedo in travel may "broach" which means breaking the surface of the water, or it may "porpoise," which means leaving the surface of the water and then falling back again. The change in acceleration produced by broaching or porpoising often is enough to set off the conventional exploder, which, of course, means no damage to the enemy and lots of trouble for the launching craft. Likewise, the shock of a mine or another torpedo explosion several hundred yards away may be sufficient to cause a premature explosion.

If the inertia element is made sufficiently callous to resist these spurious shocks it may prove insensitive to marginal types of target impact that produce small changes in velocity in the inertia element, so that the torpedo becomes a dud. A further disadvantage of this inertia type of mechanism is that those characteristics required to render the inertia element insensitive to the extraneous shocks of broaching, porpoising, or the explosion of near-by charges, will often make the response of the mechanism too slow. Indeed, physical damage to the warhead resulting from high speed impact with a hard or unyielding type of target may shatter the warhead or render the mechanism ineffective before it has completed the firing cycle.

Another type of exploder mechanism operates by displacement of a member that comes in direct contact with

the target. One form of such device in which an antenna projects from the nose of the warhead is called a "whisker" exploder. Upon striking with the target the antenna or whisker is pushed back or displaced by the target to actuate the firing mechanism; the whisker projection beyond the fairing makes the torpedo inconvenient to handle and install, and in addition there is a slight drag and reduction in speed of the missile during travel.

The present invention avoids the disadvantages of both of these types of exploders while retaining their advantages.

A principal object of the invention is the provision of a new and improved form of contact exploder for a torpedo.

Another object of the invention is the provision of an improved contact exploder that is relatively insensitive to broaching impacts or the shocks of nearby explosions.

Another object is the provision of an improved contact exploder that operates through a very wide angle of impact, irrespective of the inertia forces involved.

Another object is the provision of improved means for arming the exploder of a torpedo.

Another object is the prevention of premature shattering of the warhead or damage to the exploder before the torpedo has completed its mission.

Other objects will appear to those skilled in the art from a reading of the following specification, reference being made to the accompanying drawings, wherein, Fig. 1 is a longitudinal vertical section through an improved form of warhead in accordance with the principles of the invention, this form showing an auxiliary shell for transmitting hydraulic pressure to a conventional inertia exploder for the purpose of firing the latter.

Fig. 2 is an elevation of one of the hydraulic mechanisms shown in Fig. 1.

Fig. 3 is a vertical section of the hydraulic device of Fig. 1, taken along the line 3—3 of Fig. 1.

Fig. 4 is a longitudinal vertical fragmentary section of another form of warhead, wherein electrical means is used for detonating the exploder.

Fig. 5 is a perspective view, partially broken, of the nose of a warhead in handling or storage condition, without an auxiliary shell, and with a nose-ring cover over the exploder cavity.

Fig. 6 is a longitudinal horizontal section of still another form of warhead, in which the exploder is positioned in the nose of the warhead.

Fig. 7 is an enlarged longitudinal vertical section of the exploder of Fig. 6, taken along the line 7—7 thereof and showing the exploder in unarmed position.

Figure 8 is a longitudinal vertical section similar to Fig. 7 and showing the exploder in armed position.

Fig. 9 is a lateral vertical section of the same exploder, taken along the line 9—9 of Fig. 7.

Fig. 10 is a lateral vertical section of the same exploder, taken along the line 10—10 of Fig. 6.

Fig. 11 is a longitudinal horizontal section of the same exploder, taken at right angles to Figs. 7 and 8 and showing the exploder in firing position.

Fig. 12 is a fragmentary lateral vertical section of the same exploder, taken along the line 12—12 of Fig. 6.

Fig. 13 is a similar vertical section, taken along the line 13—13 of Fig. 6.

Fig. 14 is another lateral vertical section, taken along the line 14—14 of Fig. 11.

Fig. 15 is a wiring diagram of a circuit for arming and firing the exploder.

With particular reference to Figs. 1, 2 and 3 of the drawings, there is shown a warhead containing a main explosive charge 1 of TNT or similar material, enclosed within a metallic container 2. An exploder 3 is adapted to detonate the charge 1 at the proper time. The exploder

3 is maintained in an inoperative or unarmed position until the projectile has been launched and has traveled through the water for a predetermined distance. This distance is measured by means of a vaned impeller 4, which is rotated by the flow of sea water over the vanes. Rotation of the shaft of the impeller 4 will mechanically withdraw a detonator from within a safety chamber in the exploder 3. Thereafter, upon collision of the torpedo with its target, the missile will experience a change in velocity, and inertia will force a firing ring 5 to continue in its state of attained equilibrium. As a result, the firing ring 5 will, through a wedge action, cause a force to be applied to a trigger mechanism 6. The latter mechanism will release a firing pin that will fire the detonator and eventually explode the main charge 1. As described thus far, this matter is not novel and it does not form part of this invention.

It happens sometimes that because of the construction of the target, low relative speed, glancing impact, or other reasons, the firing ring 5 does not have sufficient force of inertia to fully displace the trigger mechanism 6, and consequently the main charge 1 is not exploded. This, of course, results in irrevocable failure of the mission for which the torpedo was made and launched.

This invention is concerned with means for positively and safely exploding the main charge 1 when, and only when, the torpedo has traveled a predetermined distance from its launching vessel and has made contact with a target along a desired portion of the nose of the missile.

In accordance with the principles of this invention, the warhead 2 is provided with an auxiliary shell 7. This shell comprises a metallic envelope that may be attached to the nose of the warhead by means of the bolts 8 or similar fastening means. The shell 7 is spaced from the nose, so that the enclosed chamber may hold a fluid 9, that may comprise air, oil, insensitive liquid explosive, or other suitable material. A gasket 11 between the shell 7 and the nose 2 prevents leakage of the fluid 9 out of the chamber or leaking of sea water within. A filling plug 12 permits filling the chamber. Both the nose 2 and the shell 7 are so contoured that the resultant fairing of the warhead is clean and streamlined. The shell 7 is of such structural rigidity that it will be deformed on impact with the target, yet strong enough to withstand launching shock, broaching, porpoising, and countermining at reasonable distances.

When the torpedo strikes a target anywhere along the line of the shell 7, that is, anywhere between an angle of 0° and 80° to its longitudinal axis, the shell 7 will be deformed. The fluid 9, being partially or substantially incompressible, will transmit the pressure of impact to an appropriate hydraulic device 13. Thence, the hydraulic pressure will be transferred through a tube 14 and will act on the firing ring 5. This pressure will be great enough to actuate the exploder mechanism even if the inertia of the firing ring 5 is of itself not sufficient for that purpose.

The hydraulic device 13 includes an apertured spider ring 15 that provides structural strength and yet permits free communication of the fluid 9 from its chamber to the device 13. The spider ring 15 is made fast to a rigid central hub 16, having a circular flange 17, to which is fixed one end of a double-walled "sylphon" type bellows 18. The other end of the bellows 18 is attached to a movable diaphragm 19. By virtue of its construction, the bellows 18 will act as a pressure multiplier.

Within the cavity in the inner wall of the bellows 18 is a liquid 22, which is sealed from both the fluid 9 and the sea water, and the space between the inner and outer walls is filled with air at atmospheric pressure. The hub 16 contains a foramen 23 that leads aft to the cavity in the bellows 18 and forwardly to a superposed cooperating nipple 24. A conduit 26 is fastened to the nipple 24 and extends downwardly to connect within the union 27. The foramen 23 in the hub 16 is open to the nipple 24 and consequently to the conduit 26. The tube 14 is joined at one end to the union 27 and at the other end to a second "sylphon" type bellows 28. The bellows 28 contains a movable diaphragm 29 having a central stud 31 that abuts the firing ring 5. The tube 14 is provided with a filling plug 32 through which the oil or similar liquid 22 may be inserted into the system.

In constructing the device, the warhead is suitably shaped for the purpose of receiving the exploder casing and the casing for the hydraulic device 13, both of which casings are bolted or otherwise attached thereto. The tube 14 is laid before the main explosive charge 1 is poured. The hydraulic device 13 is inserted into its casing, and the tube 14 and the cavities of the two bellows 18 and 28 are filled with the liquid 22 through the filling plug 32. The other portions of the torpedo may then be assembled with the warhead. To aid in handling, a cover plate 33 having a nose ring, is bolted to the spider 15. On the launching vessel, the cover plate 33 is removed and the auxiliary shell 7 is bolted to the nose 2; the intervening chamber is filled with the fluid 9. The exploder 3 may be inserted into its casing before or after the torpedo is loaded aboard. The torpedo may be loaded aboard ship, or it may be handled in the ready condition if provided with a detachable protecting member made to slip over the forward section of the warhead.

After the torpedo has been launched, the exploder 3 is armed by the impeller 4 subsequent to a predetermined travel of the projectile through the water. Any impact against the shell 7 that is sufficient to indent its surface will be transmitter to the fluid 9. The pressure will act on the rear face of the diaphragm 19 and will tend to propel the diaphragm 19 forwardly, that is, in the direction of motion of the projectile. Thence, it will be transmitted to the liquid 22, through the foramen 23, through the conduit 26, and through the tube 14. The diaphragm 29 of the bellows 28 will consequently be forced against the firing ring 5 to ignite the detonator and so explode the TNT 1 in the warhead.

It will be seen, therefore, that the explosive train of the exploder 3 will be set into operation prior to any crushing or fragmentation of the main charge in the warhead that may otherwise result from the collision. It will be further observed that the forces acting on the diaphragms 19 and 29 are in the direction of motion of the projectile, and that the inertia effect of these diaphragms will be in addition to the usual inertia effect of the firing ring 5, and can be controlled by varying the mass of the diaphragms.

In the warhead shown in Fig. 4, the pressure of impact is transmitted to the exploder 3 electrically, rather than hydraulically as in Fig. 1. The fluid 9 between the shell 7 and the nose 2 has free communication with the hydraulic device 13 through the apertured spider ring 15, and the fluid 9 bears against the posterior face of the diaphragm 19, as in the first form of this invention. In this modification, however, the bellows 18 contains a pair of electrical contacts 41 and 42 that are affixed to the stationary hub 16 in spaced relationship. One contact 41 has a flexible or elastic bend bearing against the inner side of the diaphragm 19, so that movement of the diaphragm 19 in the forward direction will act to close the contacts 41 and 42. The tubes 14 and 26 contain a multiple electrical cable 43. One branch of the cable 43 leads to a detonator 44 in the exploder 3, and another branch leads to a source of energy 45 that may be a battery or generator. The element 45 is joined with the impeller 4 so that after the exploder 3 has been armed mechanically, the arming circuit between the exploder 3 and the element 45 will be closed.

In the operation of the device, launching of the projectiles will at once start operation of the impeller 4. After the impeller has rotated a predetermined number of times, the detonator 44 of the exploder 3 will be with-

drawn from within the safety chamber to mechanically arm the exploder 3. At the same time, the impeller 4 will actuate one or more switches in the arming circuit to electrically arm the exploder 3. Thereafter, impact of the warhead with a target anywhere along the line of the shell 7 will cause pressure to be transmitted through the fluid 9 against the posterior end of the diaphragm 19. Forward movement of the diaphragm 19 will close the contacts 41 and 42 to complete the electrical firing circuit through the cable 43. As soon as this occurs, the detonator will fire. In effect, therefore, the exploder 3 will have two arming or safety features, one mechanical and the other electrical, both being controlled by the impeller 4.

Fig. 6 shows a warhead in which the exploder and the hydraulic device are combined and are positioned in a single casing 50 in the nose of the warhead along its longitudinal axis. The apex of the auxiliary shell 7 is apertured at 51 to permit sea water to enter and rotate the blades of an impeller 52. The sea water is exhausted through one or more passageways 53. Rotation of the impeller 52 is designed to actuate a plurality of gears 54 and shafts 55 to arm the exploder so that firing of a detonator 56 may be effective. The detonator 56 is held fast in a fixed ring 60. The exploder is shown in its initial or unarmed position of Figs. 6 and 7. It will be seen that rotation of the shafts 55 will act to advance from left to right a collar 57 threaded thereon. Fastened to the right or rear side of the collar 57 is a "sylphon" type bellows 58, which contains within its chamber two electrical contacts 61 and 62. The contact 61 is fixed to the collar 57, and the contact 62 is attached to a movable diaphragm 63, the said diaphragm 63 forming one end of the bellows 58. The contacts 61 and 62 are connected to respective conductors of a cable 64. The posterior face of the diaphragm 63 is open to the action of the sealed fluid 9 that has ingress through the apertures in the spider ring 15. The collar 57 has one or more arms 65 attached thereto and extending rearwardly therefrom. Fixed to the arm or arms 65 is a second collar 66, and attached to this collar 66 is a second bellows 70 that contains the mechanism for arming the exploder.

By virtue of the construction of the arm or arms 65, which are fixed to both the collar 57 and the collar 66, the collars 57 and 66 will during the arming process move from left to right in unison. Within the bellows 70 and fastened to the collar 66 is a container 67, holding a battery 68 and a condenser 69, both of which constitute elements of an arming circuit and a firing circuit, as will be more particularly described hereinafter with the aid of Fig. 15. Attached to the posterior side of the condenser 69 is a sleeve 71 formed of insulating material, and this sleeve 71, as well as the container 67, battery 68, and condenser 69, is movable along with the second collar 66. A booster charge 72 is held within the right hand portion of the casing 50. A central stud 73 is fixed relative to the casing 50, and firmly secured thereto is a second sleeve 74 formed of insulating material. This second sleeve 74 has an inner diameter slightly larger than the outer diameter of the first sleeve 71, and the first sleeve 71 is adapted to slide within the outer sleeve 74.

Freely rotatable about the central stud 73 is an arming ring 75. In its unarmed position the arming ring 75 presents a solid wall between the stationary detonator 56 and the stationary booster charge 72. The arming ring 75 contains a blow-out aperture 76, which in the arming position of the ring 75 comes into alignment with the detonator 56 and the booster 72. Pivoted at 78 (Figs. 8 and 10) to a stationary arm 77 extending from the fixed ring 60 of the casing 50 is a movable lever 79. One end of the lever 79 carries a movable detent 81, which in the unarmed position (Fig. 7) is adapted to remain in the aperture 76 for the purpose of locking the arming ring 75 in unarmed position. The other end of the lever 79 is carried by a yoke 82 attached to the container 67, so that as the container 67 is moved from left to right the detent 81 will move about the fixed pivot 78 from right to left to withdraw from the aperture 76 in the arming ring. A spiral spring 83 is positioned about the central stub 73 and has one end fixed to said stub and the other end fixed to the arming ring 75. The spring 83 is normally under tension, so that when the detent 81 is withdrawn from the aperture 76, the arming ring 75 will at once be rotated clockwise, as viewed from the left, to its arming position. A stop 84 limits the extent of rotation of the arming ring 75. An extension 85 on the yoke 82 is adapted to slide into a recess 86 in the arming ring 75 to lock it in the armed position. In the armed position of the arming ring 75, the ring 75 has rotated to such a degree that the aperture 76 is in line with the detonator 56 and the booster 72, so that ignition of the detonator 56 will be communicated to the booster 72 and eventually to the main charge in the warhead.

In addition to the mechanical arming arrangement already mentioned, the invention utilizes an electrical arming system, described hereinafter in greater detail.

The inner sleeve 71 is provided on its outer surface with two spaced electrical contacts 91 and 92. The outer sleeve 74 is provided on its inner surface with two complementary electrical contacts 93 and 94. The four contacts are so positioned along the adjacent respective surfaces of the insulating sleeves 71 and 74 that in the unarmed position of the exploder the contact 91 on the inner sleeve 71 is in conducting relationship with the contact 93 on the outer sleeve 74; these contacts 91 and 93 are joined to the cable 64 and constitute an unshorting switch, as shown more particularly in Fig. 15. At the same time, the contacts 92 and 94 are open. In the unarmed position of the exploder, the unshorting switch 91 and 93 is closed to bypass any current that might otherwise go through the detonator 56. When the arming ring 75 has been rotated to armed position—that is, when the inner sleeve 71 is wholly within the outer sleeve 74—contact between the elements 91 and 93 is broken, thereby opening the unshorting switch. At this time, when the sleeves 71 and 74 are telescoped, the elements 92 and 94 are in conducting relationship; these contacts constitute the arming switch, and, but for the open firing switch 61 and 62, complete the circuit between the condenser 69 and the detonator 56. The contacts 91, 92, 93, and 94 are all joined to the cable that leads to the battery 68 and condenser 69.

An additional safety feature is provided by a plurality of stops 95 adjustably secured to the shafts 55. The stops 95 are fixed relative to the casing 50, and in the unarmed position of the exploder they abut sleeves 96, loosely containing the shafts 55. The sleeves 96 are movable with the diaphragm 63. It will be seen from Fig. 7 that the stops 95 prevent movement of the diaphragm 63 to the left, when the exploder is unarmed, thereby keeping the contacts 61 and 62 apart and preventing accidental firing of the detonator 56. In the position shown in Fig. 8, the diaphragm 63 has moved to the right and has carried with it the sleeves 96. Such movement of the sleeves 96 allows sufficient play for the diaphragm 63 to move from right to left under impact and thereby carry with it the contact 62 into conducting relationship with the contact 61 and to complete the firing circuit. It will be noted that the collars 66 and 57 do not rotate but merely have movement of translation. On the other hand, the arming ring 75 is adapted to rotate about its axis.

The operation of the device will now be described. Initially the exploder is unarmed and is in the position shown in Figs. 6 and 7. The collars 57 and 66 and their contained structure are in the forward or left hand position. The firing switch is open; that is, the contacts 61 and 62 are spaced. The yoke 82 is to the left, and the detent 81 is to the right and within the blow-out aperture 76 of the arming ring 75. As long as the detent 81 is in

the aperture 76, the arming ring 75 cannot rotate and must remain in the unarmed position. The sleeves 71 and 74 are in their extreme uncoupled position, wherein the unshorting switch 91 and 93 is closed, and the detonator 56 is bypassed. At the same time, the arming contacts 92 and 94 are broken. It follows that the detonator 56 cannot fire for the following reasons:

(1) The firing switch 61 and 62 is open and locked in this position.

(2) The arming ring 75 is at such position that it interposes a solid wall between the detonator 56 and the booster 72.

(3) The unshorting switch 91 and 93 is closed and bypasses the detonator 56.

(4) The arming switch 92 and 94 is open.

As the torpedo speeds through the water, the sea water rotates the impeller 52. Movement of the impeller 52 rotates the shafts 55. As the shafts 55 rotate, the keyed collars 57 and 66 advance from left to right, carrying with them their associated mechanisms. The detent 81 moves about the fixed pivot 78 from right to left and withdraws from the aperture 76. As soon as the detent 81 is free of the aperture 76, the spiral spring 83 will cause the arming ring 75 to rotate until it strikes the stop 84. Subsequently, the extension 85 on the yoke 82 will move from left to right and enter the locking recess 86 in the arming ring 75 and lock the arming ring 75 in the armed position. From this moment on, the aperture 76 will be in direct alignment between the detonator 56 and the booster 72, so that explosion of the detonator 56 will be conveyed to the booster 72 through the aperture 76. While the arming ring 75 is being rotated to mechanically arm the exploder, the inner sleeve 71 advances from left to right, and in the process opens the unshorting switch 91 and 93 and closes the arming switch 92 and 94. The exploder will now be fully armed, and all safeties will have been removed except for the firing switch 61 and 62. The duration of this arming depends on the number of revolutions of the impeller 52, which number is predetermined at the outset. The dimensions are such that when the exploder is fully armed and the keyed collar 57 has advanced its full distance from left to right, the threads on the shafts 55 are still in engagement with the collar 57. Thus all rotation of the impeller 52 and the shafts 55 ceases and the exploder is held locked in the armed position.

When the auxiliary shell 7 comes into contact with a target, the shell 7 is deformed and the pressure of impact is transmitted to the enclosed fluid 9. The fluid 9 is free to enter through the apertures of the spider ring 15, and it presses against the rear face of the diaphragm 63. The pressure is sufficient to move the diaphragm 63 from right to left relative to the casing 50 and thereby close the contacts 61 and 62. This will complete the circuit between the condenser 69 and the detonator 56 and will ignite the detonator. The condenser 69 will on discharge produce better ignition of the detonator 56 than will the use of the battery 62 alone. The position of the various elements at the moment of firing is shown in Fig. 11.

It will be noted that, in the various modifications shown, any impact of the warhead against the target that results in a pressure exceeding a predetermined critical value will be sufficient to explode the warhead, irrespective of inertia effects involved. Use of the auxiliary shell permits the firing circuit to be completed and the main charge 1 to be exploded prior to the precise moment of impact of the main charge, thereby preventing physical disruption or disintegration of the main charge before it can be exploded.

By selecting for the fluid 9 a liquid of proper viscosity, lubricity, dielectric properties and corrosion inhibiting characteristics, the vital elements of the exploder mechanism which are in contact with this liquid only, are maintained in good working order. If desired, a liquid explosive of low sensitivity may be used. In such case, this liquid will explode when the warhead explodes, adding to the total effect, while contributing to the functioning of the exploder as a pressure-transmitting medium.

Furthermore, utilization of a bellows arrangement to transmit arming motion to the exploder avoids the disadvantages of the use of packing glands that are necessary when such motion is conventionally transmitted by shafts. The difficulties inherent in properly sealing off the working parts of a torpedo are well-known, and the improvement due to this invention will be obvious to those skilled in the art.

Various changes may be made in the embodiment of the invention, and it is understood that the invention is not to be limited to the forms herein illustrated and described except as specified in the following claims.

I claim:

1. A torpedo containing a warhead, an auxiliary shell spaced from the said warhead, and a pressure-transmitting relatively insensiive explosive in the space between the said warhead and the said auxiliary shell.

2. A torpedo containing an exploder, an entrapped volume of substantially incompressible fluid forming a buffer on the nose of the torpedo, and pressure transmitting means connecting the fluid volume with the exploder, being operable upon impact of the torpedo with a target for actuating the said exploder.

3. A torpedo containing an exploder, an entrapped volume of substantially incompressible fluid forming a buffer on the nose of the torpedo, fluid pressure responsive means operable by the incompressible fluid upon impact of the torpedo wih a target, and a connection between said responsive means and the exploder for actuating the said exploder.

4. In a torpedo containing a warhead and an exploder, an auxiliary shell spaced from the warhead, the said auxiliary shell comprising a material deformable upon impact against a target, a fluid filling the space between the said auxiliary shell and the warhead, and means actuated by pressure of the said fluid when the said auxiliary shell is deformed for igniting the exploder.

5. In a torpedo, an auxiliary shell spaced from the torpedo, a fluid filling the space between the said auxiliary shell and the torpedo, and means operable by pressure on the said fluid for exploding the torpedo.

6. In a torpedo, an exploder, an impeller for mechanically arming the said exploder, a firing element operable by inertia for firing the said exploder, and means self-contained by the torpedo in common with said firing element and operable upon impact of the torpedo with a target for actuating the said firing element irrespective of the inertia effect of the said firing element.

7. In a torpedo containing an exploder, an auxiliary shell spaced from a portion of the torpedo, a pressure transmitting medium between the said auxiliary shell and the torpedo, and means operable by the said pressure transmitting medium for actuating the exploder.

8. In a torpedo containing an exploder, an auxiliary shell covering and spaced from a portion of the torpedo, a fluid filling the space, a movable diaphragm open to the said fluid, a closed bellows seal including the said movable diaphragm as one of its elements, a liquid within the said seal, the said liquid being sealed from the fluid within the said auxiliary shell, a second bellows seal in contact with the exploder, and a liquid conduit from the first seal to the second seal, whereby an increase in pressure in the said fluid within the said auxiliary shell is transmitted to the first seal, through the said conduit, and to the second seal, to operate the exploder.

9. In a torpedo containing an exploder, an auxiliary shell spaced from a portion of the torpedo, a fluid filling the space between the torpedo and the said auxiliary shell, a bellows seal open to the said fluid, the said seal including a movable diaphragm so positioned that the diaphragm can move only in the direction of motion of the

torpedo, and means operable by the movable diaphragm for actuating the exploder.

10. In a torpedo, a fluid filled chamber surrounding a portion of the nose of the torpedo, an exploder, means for arming the said exploder, and means actuated by the pressure of the fluid for electrically firing the said exploder.

11. In a torpedo, a fluid filled chamber surrounding a portion of the torpedo, an exploder, an impeller for mechanically and electrically arming the said exploder, and electrical means controlled by pressure of the fluid for firing the said exploder after it has been armed.

12. In a torpedo exploder, a firing ring therefor, a first bellows confronting the firing ring, a second bellows positioned remote from said exploder, a diaphragm over said first bellows in engagement with said firing ring, and means for transmitting the pressure of an impact at said second bellows to said diaphragm to actuate the firing ring of the exploder.

13. In an exploder for torpedoes, a detonator embodied in the exploder, two relatively movable insulating sleeves, said sleeves having two pairs of electrical contacts on their contiguous surfaces, one pair being normally closed and controlling an electrical circuit that shorts the said detonator in the unarmed condition of the exploder, the second pair being normally open and leading to an arming circuit embracing the detonator, and means for moving the said sleeves whereby the shorting contacts are opened and the arming contacts are closed.

14. In an exploder for torpedoes, a detonator, an impeller actuated by the travel of the torpedo through the sea water for arming the said detonator, a source of electrical energy, an electrical circuit connecting the said source of electrical energy to the said detonator, the said circuit including at least two switches, one of the said switches being open and another being closed during the unarmed position of the exploder, means operating by

instrumentality of the impeller for closing the open switch and opening the closed switch at substantially the same time, and inertia-free means operable from the said source of electrical energy for firing the said detonator upon impact of the torpedo against a target.

15. In a torpedo exploder including an exploder electrical circuit, an arming mechanism comprising an element which is rotative by the forward progress of the torpedo, a rectilinearly operable element adapted to be actuated by the said rotative element, electrical contacts for closing the exploder electrical circuit, a bellows containing the contacts in sealed confinement being actuated by rectilinear operation of the said rectilinear element for closing the exploder electrical circuit.

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