Aug. 13, 1946. N. HERZMARK 2,405,694

DEFENSE SYSTEM

Filed Aug. 11, 1942 3 Sheets-Sheet 1

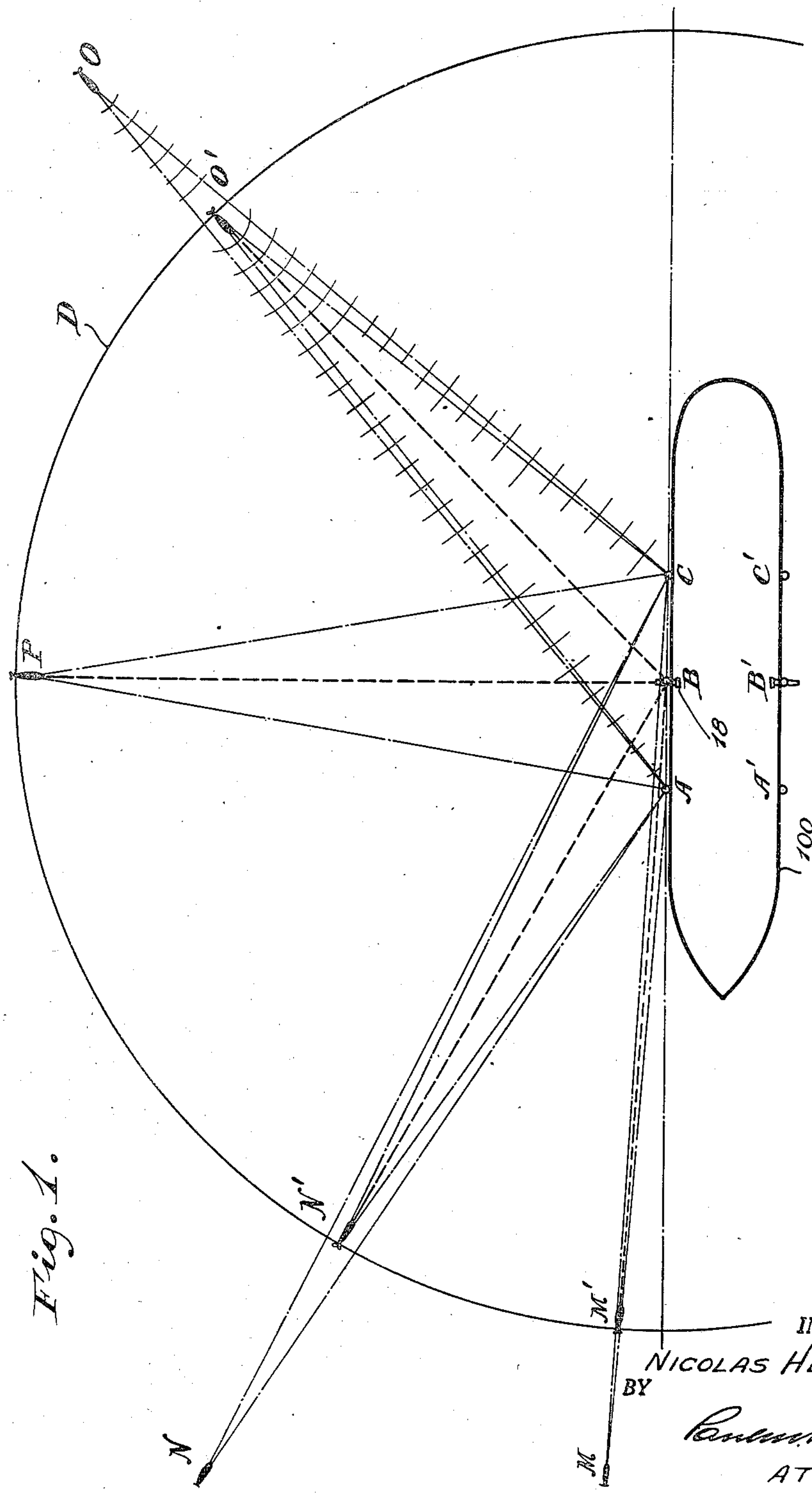

Fig. 1.

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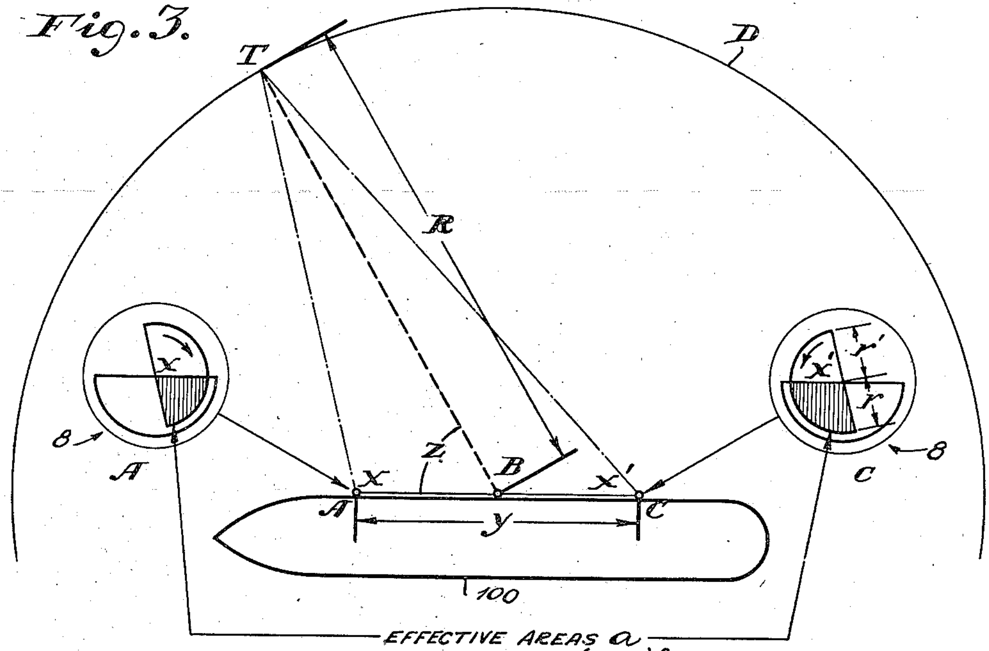
Aug. 13, 1946. N. HERZMARK 2,405,694
DEFENSE SYSTEM
Filed Aug. 11, 1942 3 Sheets-Sheet 2

Fig. 3.



$$x\,(x') = \cos^{-1}\left[\frac{\frac{y}{2}\,(\pm)\,R\cos Z}{\sqrt{\frac{y^2}{4}+R^2 \pm Ry\cos\theta}}\right]$$

$$a = \left(\frac{r+r'}{2}\right)^2 \pi \times \frac{180-x}{360}$$

Fig. 2.

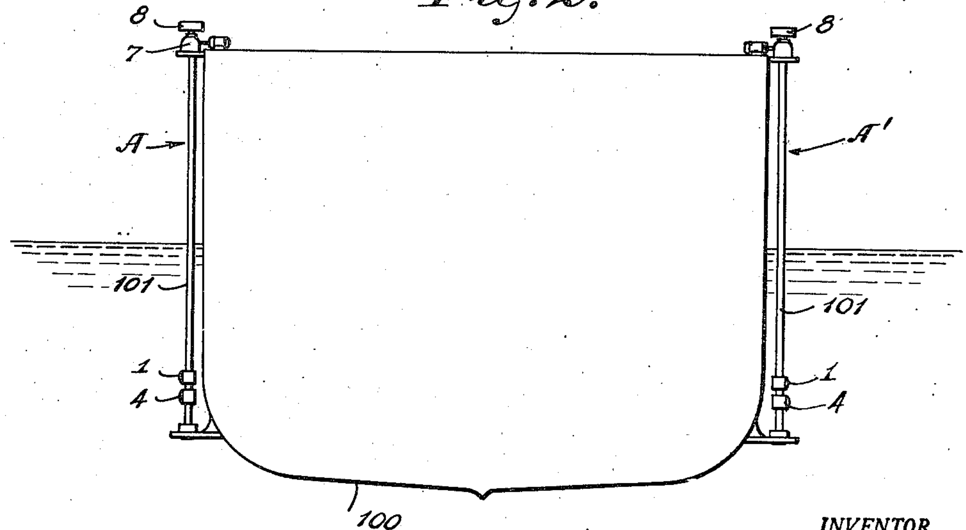


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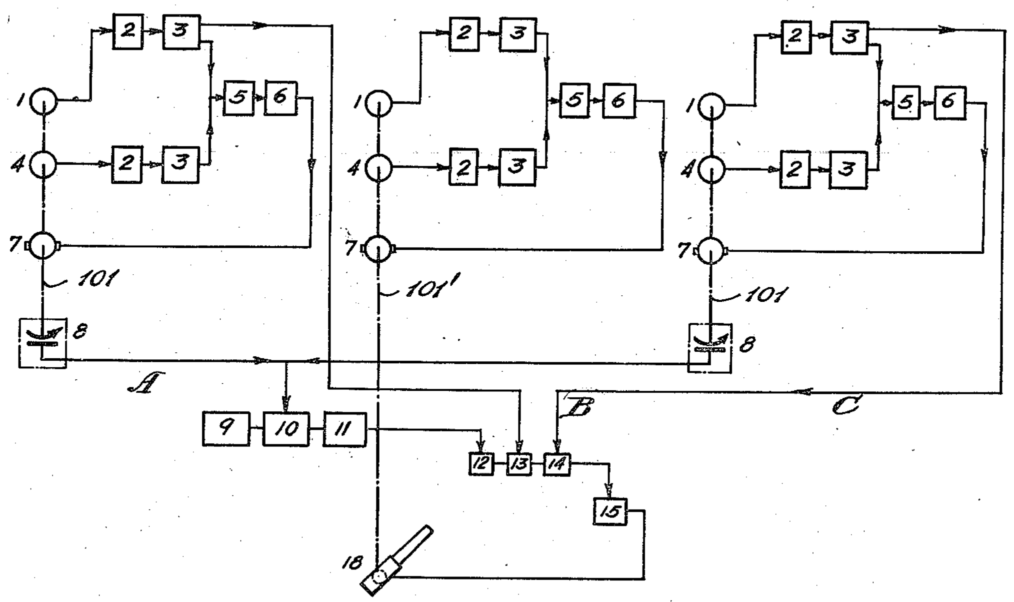
Fig. 4.



1 – PRESSURE HYDROPHONE
2 – HIGH PASS FILTER
3 – AMPLIFIER AND RECTIFIER
4 – VELOCITY HYDROPHONE
5 – RECTIFIER BRIDGE
6 – POLARIZED RELAY
7 – BI-DIRECTIONAL MOTOR
8 – VARIABLE CONDENSER

9 – OCCILLATOR
10 – CAPACITY BRIDGE CIRCUIT
11 – AMPLIFIER AND RECTIFIER
12 – RELAY
13 – "
14 – "
15 – FIRING RELAY
18 – GUN

Fig. 5.

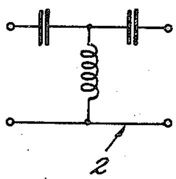


Fig. 6.

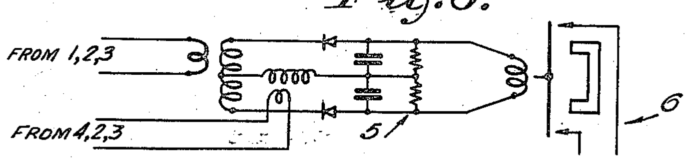
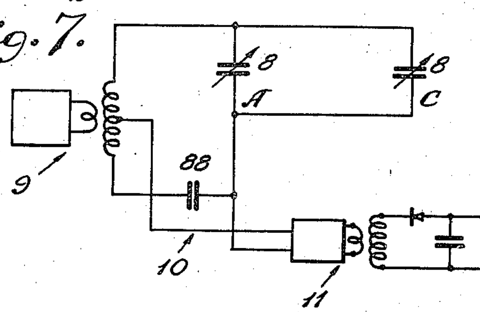


Fig. 7.



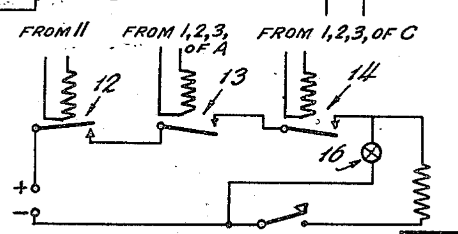


Fig. 8.

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UNITED STATES PATENT OFFICE

2,405,694

DEFENSE SYSTEM

Nicolas Herzmark, Indianapolis, Ind.

Application August 11, 1942, Serial No. 454,393

2 Claims. (Cl. 89—41)

1

This invention relates to a defense system and means employed therein for destroying missiles directed against objects, at a safe distance from and before they may reach such objects.

One of the objects of the present invention is the provision of co-ordinated sound responsive means for the detection of a missile approaching from any direction, and means for orientating a defense instrumentality against such missile, and further means for causing such instrumentality to destroy the missile at a predetermined, safe distance from the defended object.

Another object of the present invention is the provision of a defense system against projectiles or the like, wherein is employed a combination of at least three operatively interconnected and cooperating units for detecting and locating such projectile while it approaches its object, and wherein one of the units controls a defense instrumentality, such as a mortar or gun, and wherein the two other units control the firing mechanism of such defense instrumentality so that when the projectile nears a certain danger zone the charge of the defense instrumentality is loosed in front and against the projectile for destroying it before it reaches the danger zone.

A still further object of the present invention is to provide a defense system against projectiles, such as torpedoes, and in which system are employed electrically energized, sound-sensitive units cooperating with one another, and wherein one of the units controls the training against such projectile of a mortar or gun, adapted to shoot depth charges or the like, whereas at least two other units control the firing of the gun, and wherein the gun is so mounted that it will be constantly maintained at a certain elevation, and in which elevation such gun may be swung in a circular curve within an angle of at least 180°, and wherein the gun is adapted to eject its charge for a certain distance from the gun, and wherein electrically controlled means are provided to discharge the gun against an approaching projectile when it reaches a point near the predetermined shooting distance within the aforesaid half circle.

A still further object of this invention is to provide in a defense system against sound emitting projectiles or the like, such as torpedoes, a plurality of sound responsive control units adapted to react to the emission of sound emanating from such torpedoes, and wherein one of the units controls the constant training of a mortar or gun against the approaching torpedo, while the other units control the firing mechanism of such mortar or gun, and wherein each of the units employ pressure and velocity actuated microphones or hydrophones, motive means for operating the latter, means for co-ordinating the operation of the units, and wherein two units at both sides of the gun controlling unit are equipped with variable condensers, connected in parallel, and wherein these condensers are so designed that their total capacity, which latter is being constantly checked against a predetermined or standard capacity of the co-ordinating means, remains constant when the condensers are simultaneously operated in such a way that the vertical center plane passing through the velocity microphones intersect at any point of a half circle, the radius of which corresponds to a predetermined shooting distance of the gun, and that their total capacity becomes different from the aforesaid standard capacity when the vertical planes passing through the microphones intersect at a point beyond such half circle.

2

Still another object of the present invention is to provide with my microphone-operated units the aforesaid condensers of a special design to render them functioning in the manner indicated, and to provide a formula for the proper construction of the rotor plates of the condensers.

A still further object of this invention is to provide a formula for the calculation of angles of ever-changing triangles formed between a constant base and two intersecting vertical planes, and wherein the base conforms with a line connecting two outer units, and which line passes through a central unit, and wherein the intersecting vertical planes correspond to the central planes passing through the pressure and velocity microphones of the outer units.

The foregoing and still further objects and important advantages of the present invention will become more fully understood from the ensuing description, taken in connection with the accompanying drawings, which latter, while showing specific arrangements of the present invention, by no means are intended to limit the disclosure to the actual showing, and wherein

Fig. 1 is a diagrammatical top view of a vessel equipped with my defense system;

Fig. 2 is an enlarged end elevation of a vessel showing the arrangement of few of the component parts of my system;

Fig. 3 is a diagrammatical illustration of a vessel equipped with my defense instrumentalities, with the condensers employed in the end units thereof being shown in greater detail, together with a formula pertaining to their construction, and another formula for the calculation of certain angles;

Fig. 4 is an illustration of a diagram showing control units forming part of my system; and

Figs. 5, 6, 7 and 8 represent detail diagrams of some of the control devices employed in Fig. 4.

Up to the present time numerous attempts have been made for defending moving or stationary objects, such as ships, lighthouses, gun emplacements, etc., against torpedo attacks by submarines, and it has been determined that the best way of defense against torpedos is the destruction of such torpedos at a safe distance from, and before they may do any damage to the objects against which they are directed. Similarly, in the defense against submarines or any other attacking ships, depth charges ejected from mortars, guns or other devices to destroy the offenders have been found very effective.

The present invention utilizes the heretofore gained knowledge in an improved and most positive manner, and employs an automatic defense system whereby a projectile, such as a torpedo, may be detected and followed until it reaches a convenient, but a sufficiently safe distance from the defender, at which it may be destroyed before becoming effective.

Referring now to Figs. 1 and 2, numeral 100 denotes the body of a ship, equipped at both port and starboard with a combination of at least three electrically energized control units, indicated at A, A1, B, B1, C and C1. Each of these units is composed of a shaft 101, 101 and 101' (see Fig. 4), extending vertically alongside the ship, a combination of a pressure hydrophone 1 and a velocity hydrophone 4, and a bi-directional motor 7, all mounted upon the respective shafts. The two end or exterior units A and C are additionally equipped with variable condensers 8. Interior unit B has no condenser. All of the units are provided, in addition to the pressure and velocity hydrophones and the motor, with electrically energized controls, responsive to sound vibrations received by the two hydrophones, composed of individual sets of high-pass-filters 2 and amplifiers and rectifiers 3 for each of the two types of hydrophones. The amplifier and rectifier 3 of both hydrophones in each unit are connected with a rectifier bridge 5 and a polarized relay 6. These relays control the operation of bi-directional motors 7, and the direction of rotation at which they are to operate.

Condensers 8 of units A and C are in parallel with one another, and their combined lead connects with a bridge circuit 10, which is energized by an oscillator 9. Within the bridge circuit there is provided a certain predetermined or standard capacity, which corresponds to the total capacity of variable condensers 8, when the latter are at a certain setting. Bridge circuit 10 is connected to an input amplifier and rectifier 11, from which extends a lead to a relay 12. This relay is connected with another relay 13, and through this relay to a third relay 14. Amplifier 3 of pressure hydrophone 1 in unit A is also connected with relay 13. Third relay 14 connects with amplifier and rectifier 3 of pressure hydrophone 1 in unit C and with firing relay 15, which controls the firing mechanism of mortar or gun 18.

Mortar or gun 18 is turned by bi-directional motor 7, through hydrophone shaft 101' of unit B, within an arc of at least 180 degrees, whereby its aim towards an approaching torpedo is constantly maintained. The gun is preferably supported in a ball and socket mounting, and its sighting angle is kept constant, against the rolling of the vessel by a heavy plumb bob, holding the gun in its mounting at the desired angular elevation.

Fig. 5 diagrammatically illustrates the interior arrangement of the high-pass-filter 2 employed in each of the units with each of the hydrophones, and is designed to pass impulses of a certain frequency only. In Fig. 6 the arrangement of rectifier bridge 5 is shown, together with the polarized relay 6, which controls the operation of motors 7. Fig. 7 illustrates a detail arrangement of oscillator 9, variable condensers 8, bridge circuit 10, with its constant capacity 88, amplifier 11 and its output to relay 12, while Fig. 8 is a diagrammatical illustration of relays 12, 13 and 14 and their connection with firing relay 15. In that figure a pilot light 16 and a manually operable cut-out switch 17 are also indicated. While the instrumentalities illustrated in Figs. 5 to 8 are specifically constructed for their intended purposes, the diagram shown in Fig. 4 includes additional devices enumerated in the legend of that figure. These additional devices, such as pressure and velocity hydrophones, amplifiers, rectifiers, etc., are well known in the art and require no further explanation. However, their arrangement and cooperation with one another and with the instrumentalities shown in detail in Figs. 5 to 8, as defined in the diagram of Fig. 4, comprises a novel combination designed to provide the desired new results as will become hereinafter evident.

Referring to Fig. 3, ship 100 is provided with a combination of control units A, B and C, extending downwardly alongside the ship. End units A and C are equipped with variable condensers shown diagrammatically and enlarged at 8. In this figure there is illustrated a triangle, the base of which forms a line extending between units A and C, and is indicated at Y. This line passes through unit B. The two sides of the triangles AT and CT intersect at a point of circle D, indicating the danger zone. The radius of circle D corresponds to a line connecting apex T of the triangle with the center of base Y, at the unit B.

Fig. 3 contains two formulas, one for computing angles X and X' of the variable triangle A, T and C, which angles correspond to those between the straight edges of the movable and stationary blades of the respective condensers of units A and C, and the other formula is intended to facilitate the computation of the effective capacity areas a of each of the condensers. The derivation of the formula for angles x on x' is as follows:

In this formula angle Z (Fig. 3) is also called θ.

Assume that a perpendicular h is drawn in Fig. 3 from point T against a left-hand extension of base y of triangle ATC.

The distance between point B and the point of intersection of h with the extension of y is b.

$b-y/2$=base of triangle having as one of its sides the normal h, the other side being line TA.

$b+y/2$=base of triangle having as one of its sides the normal h, the other side being line TC.

Tan x=−tan $(180-x)$

(Formula 1)

$$\tan x=-\frac{h}{b-y/2}=\frac{R\sin\theta}{R\cos\theta-y/2}$$

(Formula 2)

$$\tan x'=\frac{h}{b+y/2}=\frac{R\sin\theta}{R\cos\theta+y/2}$$

Knowing the tangent of an angle, the cosine can be found. (Formula 1.)

(Formula 3)

$$\operatorname{Cos} x = \frac{-R\cos\theta - y/2}{\sqrt{R^2+\frac{y^2}{4}-Ry\cos\theta}} = \frac{y/2 - R\cos\theta}{\sqrt{R^2+\frac{y^2}{4}-Ry\cos\theta}}$$

From Formula 2

(Formula 4)

$$\operatorname{Cos} x' = \frac{R\cos\theta + y/2}{\sqrt{R^2+\frac{y^2}{4}+Ry\cos\theta}}$$

The derivation of the formula for computing the effective condenser area a is as follows:

Let A equal the total effective capacity area, that is when the variable plates fully coincide with or are completely opposite the fixed plates.

Let a be the effective capacity area, that is when the variable plates are not in completely opposite position to the fixed plates.

$r+r'$=diameter of variable plates

Effective area $a=\frac{r^2}{2}\times$included angle of sector, in this case $180-x$.

$$\frac{r^2\times(180-x)}{r^2\times 180}=\frac{a}{A}$$

$$\frac{180-x}{180}=\frac{a}{A}$$

The effective area a of the variable plates=

$$\frac{\pi}{2}(d/2)^2\times\frac{a}{A}=\frac{\pi}{2}\left(\frac{d}{2}\right)^2\times\frac{180-x}{180}=\left(\frac{r+r'}{2}\right)^2\pi\times\frac{180-x}{360}$$

The movable blades of variable condensers 8, 8 are intended to be operated simultaneously, and their total effective capacity must remain constant and must match the fixed capacity of balancing condenser 88 in capacity bridge circuit 10 before gun 18 may be fired.

Such condition is effected whenever the vertical center planes passing through the velocity hydrophones of the respective condensers meet at any point of danger circle D, such as at point T of triangle ATC. These vertical center planes are represented by the sides AT and CT of that triangle, and it is assumed that the straight edges of the movable blades of the respective condensers coincide with these planes.

When these planes meet at a point outside of circle D, the total effective capacity of the two condensers becomes different from the fixed capacity of balancing condenser 88, and gun 18 can not be fired.

The arrangement of the support for gun or mortar 18, controlled by unit B, is such that it permits not only the ready movement of the gun within at least a half circle, but the mounting of the gun is so arranged that the gun will be constantly maintained at a uniform elevation in respect to the horizontal plane, so that when the gun is discharged it will place its missile at a distance approximating, but preferably somewhat short of the radius of danger circle D.

The mortar or gun is equipped with a firing device controlled by the combined arrangement shown in the lower portion of Fig. 4, and which comprises oscillator 9, capacity bridge circuit 10, amplifier and rectifier 11, the three relays 12, 13 and 14 and the firing relay 15. Relay 12 is being energized by the output from amplifier and rectifier 11, and makes contact when it is de-energized. Relay 13 is controlled by amplifier-rectifier 3 for hydrophone 1 of unit A, and relay 14 by amplifier-rectifier 3 for hydrophone 1 of unit C. These relays make contact when their respective pressure-actuated hydrophones receive sound impulses of a sufficient intensity. When all three relays 12, 13 and 14 make contact at the same time, firing relay 15 becomes energized and operates the firing mechanism of gun 18.

Operation

It has been determined that sound vibrations emitted from a passing ship, or from the moving vessel itself equipped with my system, are below a certain sound frequency, for instance below 5000 vibrations per second. It has been also established that projectiles, such as torpedoes, emit sound frequencies above the usual sound of ships, say above 5000 vibrations per second, due to the fact that their propellers are small and therefore are operating at a very high speed.

The pressure hydrophones employed in my system, as well as the velocity hydrophones, are designed to pick up sounds of any vibration, but to induce impulses in the electrical part of my system only when these vibrations exceed the range of normal, low vibration frequencies of ships, and approximate the high vibration frequencies of an approaching torpedo. Thus when pressure hydrophones 1 pick up a sound corresponding to that emitted by a torpedo, the vibration impulses will be translated to the electric portion of my system and will cause the units to operate, that is shafts 101, 101 and 101' will be turned by motors 7 until the velocity hydrophones will be in line with the sound, at which moment the turning motion of the units stops.

To understand this operation in detail the following explanation is in place. Assume that an approaching torpedo emits a sound which is picked up by the pressure hydrophones of all three units. The sound is electrically transmitted to high-pass-filters 2 of the pressure hydrophones, passes to amplifiers and rectifiers 3 thereof, and from there to rectifier bridges 5 and polarized relays 6. These relays becoming energized will cause the operations of motors 7, which will turn shafts 101, 101, and 101'. Both pressure and velocity hydrophones turn with these shafts. The moment the velocity hydrophones are in a position to directly pick up the sound, which position may be called the zero reception, the impulses received by the velocity hydrophones are propagated through their high-pass-filters 2, their amplifiers and rectifiers 3, to rectifier bridges 5, and to the polarized relays 6. At that moment both contacts in the relay break, see Fig. 6, in consequence thereof motors 7 stop the rotation of the shafts and of the hydrophones.

As the torpedo approaches nearer and the velocity hydrophones fail to receive the sound impulses, while the pressure hydrophones still are receiving such impulses, one of the contact points in the polarized relay 6 will close and cause the operation of motors 7. Thus the entire hydrophone assembly is turned in the direction towards the sound, until the velocity hydrophone again reaches zero reception position, at which moment the operation of the motors will stop. Bridges 5 and polarized relays 6 operate so that a direct current output is produced, the polarity of which depends upon the presence or absence of a phase inversion between the two signals received by the two hydrophones of each unit.

The polarized relay is designed to either make contact at one or the other end of its switch, or to keep the latter open. Depending upon which of the switch ends makes contact, motors 7 will turn in one or the other direction, until the velocity hydrophone is in zero position, that is when its diaphragm is in line with the sound. As the sound direction changes with the movement of the torpedo, motors 7 will always follow. At the zero position of the velocity hydrophone the switch in relay 6 will open, and the operation of motors 7 will stop. Referring to Fig. 6, two inputs are indicated, one from pressure hydrophone 1, the other from velocity hydrophone 4. Both impulses are of alternating currents, which are converted by rectifier bridge 5 to produce direct current output to polarized relay 6. Depending upon whether or not the two alternating input voltages introduced into bridge 5 are in phase or out of phase, the upper or lower switch contacts of relay 6 will close, while both contacts will remain open if there is no current in either one or both inputs, or if the two currents differ in frequency. In consequence of the aforesaid phase inversion, each unit individually controlled by its polarized relay 6 is caused to respond in its operation to the sound impulses received by each individual unit.

The variable condensers of units A and C and their relation to each other has been already explained, yet their operation must be repeated in order to present a clear picture of the function of the device. Their total capacity remains constant when they are simultaneously so turned that the vertical planes passing through their respective velocity hydrophones meet at a constant predetermined distance from unit B. When, however, these two planes meet at a point outside of danger circle D, the total effective capacity of the condensers will differ. The condensers are connected in parallel, and their total capacity is being continuously matched against the capacity of the capacity bridge circuit 10, which is energized, by oscillator 9. While the condensers are at a position at which their total effective capacity does not match the capacity of fixed condenser 88 of the bridge circuit 10, the latter will not be balanced, and current will be delivered to the input amplifier and rectifier 11. The amplified voltage being rectified, will keep relay 12 open.

When the condensers are in a position at which their total capacity equals the predetermined capacity value of bridge circuit 10, the latter becomes balanced and no voltage is passed to amplifier and rectifier 11. At that moment relay 12 becomes de-energized and closes the firing circuit across the relay. At that position of relay 12, firing relay 15 may become energized and could actuate the firing mechanism of gun 18, which latter is constantly trained in the direction towards the target and is maintained at an elevation to place its charge, when fired, preferably in front of the approaching torpedo.

It is readily conceivable that the firing mechanism may be actuated when units A and C accidentally assume their correct position, at which the total capacity of their condensers equal the pre-determined or standard capacity 88 of bridge circuit 10. In order to avoid the firing of the gun, due to such accidental setting of condensers 8, relays 13 and 14 are interposed. They are energized only when signals are received by the pressure hydrophones of both units A and C. If relays 13 and 14 become energized while relay 12 is de-energized and makes contact, the circuit between relays 12, 13 and 14 is closed, and firing relay 15 may then operate.

This arrangement may be readily understood by consulting Fig. 8 showing relays 12, 13 and 14, and their respective arrangements. The operation of firing relay 15 may be prevented by opening manually operable switch 17. A pilot light 16 is provided for indicating the closed or open position of the relay circuit.

It is to be borne in mind that sound emitted from sources other than those of projectiles or torpedoes must not energize any one of the units. For this reason it was determined to employ a high-pass-filter 2, such as shown in detail in Fig. 5, which suppresses all signals below a certain minimum frequency. It has been found that sound vibrations emitted from torpedoes exceed 5000 vibrations per second. Filter 2 is designed to block sound vibrations of less than 5000, thus preventing ship noises and other noises below this frequency from interfering with the operation of the mechanism.

The operation of the sound controlled units in respect to approaching torpedoes from different directions is clearly illustrated in Fig. 1. It will be seen that my system may detect, follow and effectively deal with torpedoes approaching at even acute angles, such as in the case of torpedo M, M′ at the left of the figure.

Similarly torpedoes N, N′, O, O′, and P, approaching from other directions, become vulnerable. At the moment any of these torpedoes approach a point near or at danger circle D, mortar or gun 18 fires a depth charge in front of the missile. Obviously, more than one group of units A, B and C would be required for effectively combatting a simultaneous attack by two or more torpedoes.

In the foregoing description specific arrangements of my system have been described. Similarly the drawings illustrate only one form of a control mechanism, chiefly electrical in nature. In Figure 1 of the drawings is indicated but one set of units for each side of vessel 100. It is to be understood, of course, that more than two sets of units may be employed along one side of a vessel, and that the placement of such sets of units in relation to the body of the vessel may be chosen for complete protection of its hull, so that no part thereof may remain vulnerable.

Inasmuch as all the aforesaid modifications are quite obvious and depend upon the basic three unit arrangement of my system, specific illustrations of such modified forms are not shown, nor are they specifically described. In any event, however, all possible modifications of my system will require the employment of a combination of cooperative means which will produce the desired results. These combinations will include the employment of at least one pressure hydrophone and a velocity hydrophone, or their equivalents, as well as motive means for turning the combined hydrophones, and means whereby these motive means may be operated in one or the other direction in response to vibratory impulses received by the combination of the two hydrophones.

In the specification particular emphasis is placed on the defense of ships against approaching torpedos. The same or similar arrangements may be readily employed for coastal defense or for the defense of stationary objects, and against missiles or projectiles which are not torpedos, but emit sounds which may be detected by the instrumentalities employed, and which missiles may be destroyed before they reach the defender objects.

Having thus defined the high points of my invention, it will be quite readily understood that neither the specific description nor the specific illustrations are intended to limit my invention to the instant presentation, and that I shall have the right to make changes, improvements and rearrangements of the different instrumentalities employed, without departing from the broad scope of my invention, as set forth in the annexed claims.

I claim:

1. In a defense system against projectiles or the like, the combination of at least three spaced, electrically interconnected sound detector units in cooperation with one another, and comprising two outer and one inner unit, a gun or the like, a mounting for the gun for constantly maintaining it at a certain angle of elevation and for facilitating its swing within an angle of at least 180°, whereby the gun is adapted to shoot a charge for a predetermined distance, said inner unit being designed to train the gun towards an approaching projectile, said outer units being adapted to locate such projectile and to actuate the firing mechanism of the gun when the projectile reaches a point near the predetermined shooting distance of the gun, all of said units comprising pressure-and velocity-microphones mounted on a shaft and a reversible motor for actuating the shaft, said outer units also having variable condensers operative with their respective shafts, a high-pass filter and an amplifier and rectifier connected with each microphone of each unit, a rectifier bridge and a polarized relay forming parts of each unit, said polarized relays controlling the operation and the direction of operation of the respective motors of each unit; means for controlling the firing mechanism of the gun, said means comprising an oscillator, a bridge circuit energized by said oscillator and being controlled by said variable condensers of the outer units, an amplifier and rectifier, a relay controlled by the latter, another relay controlled by the amplifier and rectifier of the pressure microphone in one of the outer units, a third relay controlled by the amplifier and rectifier of the pressure microphone in the other outer unit, and a firing relay controlled by the three last-mentioned relays.

2. In a defense system against projectiles or the like, the combination of at least three spaced, electrically interconnected sound detector units in cooperation with one another, and comprising two outer and one inner unit, a gun or the like, a mounting for the gun for constantly maintaining it at a certain angle of elevation and for facilitating its swing within an angle of at least 180°, whereby the gun is adapted to shoot a charge for a predetermined distance, said inner unit being designed to train the gun towards an approaching projectile, said outer units being adapted to locate such projectile and to actuate the firing mechanism of the gun when the projectile reaches a point near the predetermined shooting distance of the gun, all of said units comprising pressure- and velocity-microphones mounted on a shaft and a reversible motor for actuating the shaft, said outer units also having variable condensers operative with their respective shafts, a high-pass filter and an amplifier and rectifier connected with each microphone of each unit, a rectifier bridge and a polarized relay forming parts of each unit, said polarized relays controlling the operation and the direction of operation of the respective motors of each unit; means for controlling the firing mechanism of the gun, said means comprising an oscillator, a bridge circuit energized by said oscillator and being controlled by said variable condensers of the outer units, an amplifier and rectifier, a relay controlled by the latter, another relay controlled by the amplifier and rectifier of the pressure microphone in one of the outer units, a third relay controlled by the amplifier and rectifier of the pressure microphone in the other outer unit, and a firing relay controlled by the three last-mentioned relays, said condensers being connected in parallel and being so designed that their total capacity, checked against a predetermined or standard capacity of said bridge circuit, remains constant when they are simultaneously operated in such a way that the vertical central planes passing through the velocity microphones intersect at any point of a half-circle, the radius of which corresponds to the predetermined shooting distance of the gun, and that their total capacity becomes different from such standard capacity when the aforesaid microphone planes intersect at points beyond that half-circle.

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