TORPEDO GUIDANCE SYSTEM

Method and means of guiding a torpedo along a collision course with a moving target ship, wherein the torpedo maintains a predetermined substantially constant lead angle with respect to the target ship. The lead angle is maintained constant by adjusting the torpedo speed as it travels toward the anticipated collision.

11 Claims, 3 Drawing Figures
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TORPEDO GUIDANCE SYSTEM

The present invention relates generally to torpedo warfare tactics and in particular is an improved method and means for guiding a torpedo toward the anticipated path of a moving target ship to timely effect collision therewith and destruction thereof. In even greater particularity, the subject invention is a method of guiding a torpedo along a collision course with a moving target ship, wherein said torpedo maintains a predetermined substantially constant lead angle with respect to said ship, said lead angle being maintained by adjusting the torpedo speed as it travels toward the anticipated ship course.

In the past, several methods of torpedo warfare have been employed to destroy enemy target ships. For example, in some instances a torpedo has been aimed at a target while still in its launching device and then fired. In this case, if the target were a moving target, the aiming procedure would include a lead angle to effect a torpedo trajectory that would actually constitute a collision course with the moving target. Also, in some instances, acoustic homing guidance systems were incorporated in torpedoes which either passively listened to or actively echo-merged on a moving target and then positioned the control surfaces thereof in such manner as to guide the torpedo to the target. In the latter instance, speed control may also have been combined with the control surface—attitude guidance system to enable the speed of the torpedo to be increased in event it must race to catch the moving target.

Such methods are quite satisfactory for many practical purposes; however, they do have some disadvantages which, under certain circumstances, tend to limit their effectiveness. In the former case, aiming errors are very possible and usually quite costly, both in terms of expenditures and firing ship safety. In the latter case, it is usually necessary for the homing torpedo to chase the target ship. This, in turn, necessitates the torpedo traveling at speeds that are considerably higher than that of the target. Not only this require an unduly large powerplant, the required higher noise output from the torpedo makes it considerably more vulnerable to detection and countermeasure operations.

Wire-guided torpedoes have also been used successfully in some instances, but their power requirements, high speed tactical maneuvering, and vulnerability ostensibly leave a great deal to be desired for reasons similar to those presented in the discussion of the aforementioned torpedo warfare tactics. Accordingly, the optimizing thereof by means of improved operational procedures definitely appears to be a desirable adjunct thereto at this time.

The instant invention overcomes many of the disadvantages of the prior art, in that the torpedo employing it quietly runs and maneuvers at a speed that is low compared to that of the target ship, especially during the early part of the operation. The operational procedure is such that the target ship approaches the torpedo at a speed much greater than vise versa. This, in effect, facilitates the use of low torpedo speeds against fast ships. Moreover, due to the relatively low speed and concomitant low noise level of the torpedo as it travels along its collision course with the target, its probability of being detected by the passive sonar of the target ship is considerably reduced, and, in addition, the active sonar detection thereof is made extremely difficult due to the fact that its slow speed produces a doppler frequency shift that is so small as to be of doubtful value in detection of the torpedo by the ship's sonar. Hence, it would appear that during many warfare tactical maneuvers, the method and means incorporated in this invention are considerably superior over those of the prior art.

Accordingly, it is, therefore, an object of this invention to provide an improved method and means for destroying an enemy target ship.

Another object of this invention is to provide an improved method and means for guiding a torpedo along a collision course with a target. Still another object of this invention is to provide a method and means for guiding a low speed torpedo toward a relatively higher speed target ship.

A further object of this invention is to provide a method and means of homing on a target ship as a result of speed control rather than directional control.

A further object of this invention is to provide a method of homing a torpedo on a target ship by employing a substantially fixed lead angle thereon that approximates a right-angle.

Another object of this invention is to provide a method and means of homing the torpedo guidance system which regulates its speed in such manner that the relative bearing of the target ship with respect to the torpedo remains approximately constant.

Another object of this invention is to provide an improved homing torpedo guidance system which uses acoustic energy in the lower sonic frequencies, wherein the acoustic output of the target ship is greater, and the acoustic transmission loss from the ship to the torpedo is less.

Still another object of this invention is to provide a combined wire-guidance and automatic speed control method for effecting destruction of a target ship.

Another object of this invention is to provide an improved torpedo homing system which incorporates the method and means for reversing the popular concept of an attacking torpedo.

Other objects and many of the attendant advantages will be readily appreciated as the subject invention becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying figures of the drawings wherein like reference characters designate like parts and wherein:

FIG. 1 is a block diagram representing the associated components involved in effecting the subject invention;

FIG. 2 is a pictorial representation of the operational procedures incorporated in the subject invention; and

FIG. 3 is another pictorial representation of the operational procedures which is intended to occur during the torpedo attack period of the method involving this invention.

Referring now to FIG. 1, there is shown a firing vessel control 11 which may be located in any suitable control vessel such as a submarine or the like and which is connected by means of a control cable 12, usually a single wire, to a guidance system 13 installed in torpedo 14, intended to the guided. Guidance system 13 has a pair of outputs, one of which is supplied to a rudder controller 15 and the other of which is supplied to a motor speed and reversing controller 16. The output of rudder controller 15 is connected by means of a shaft or other suitable connector to the rudder 17 of the torpedo, which, of course, is used for directional guidance of the torpedo as necessary to make it functional.

A target-bearing deviation system 18 of any of the well-known, conventional types (such as, for example, the type shown at page 275 of the book entitled Fundamentals of Sonar by J. W. Horton, published in 1957 by the United States Naval Institute, Annapolis Maryland) has one of its outputs (perhaps taken from the indicating meter inputs) supplied to the proper input of the aforesaid compatible motor speed and reversing controller 16, in order to provide target position information thereto at any given instant so that the speed of the torpedo may be timely adjusted as necessary to effect a guidance function, as will be explained in more detail in the discussion of the operation of the subject invention given below.

Another output from target bearing deviation system 18 is coupled through another conductor cable 19 to the aforesaid firing vessel control 11, in order to supply target position information thereto that may be useful in effecting the operational method of this invention by human or other operators. Obviously, if so desired, cables 12 and 19 may be one and the same cable or wire, and the information and intelligence signals conducted thereon may be sent on a time shared or multiple-frequency basis, as is conventional in the electronic and communications arts, since so doing would be well within the purview of one skilled in the art having the teachings herewith presented. Thus, so doing would facilitate the manipulation of said cable during torpedo attack positioning and the like.
The output of motor speed and reversing controller 16 is coupled to a reversible direct current motor 21 which, in turn, drives the torpedo screws 22 at whatever speed is dictated by the combined target bearing deviation system 18 and motor speed and reversing controller 16, so as to keep torpedo 14 on the proper collision course with the predetermined moving target ship.

A pair of electroacoustical transducers 23 and 24 are spatially disposed in the side of the torpedo and timely receive acoustic energy from the target vessel; this information is then respectively supplied to the appropriate inputs of target bearing deviation system 18 to timely effect relative target determination.

The operation of the subject invention will now be discussed briefly in conjunction with FIGS. 1 through 3 as follows:

As illustrated in FIG. 2, torpedo 14 is launched from a submarine boat or other suitable firing vessel 26 and wire-guided to an opportune attack position where it may readily acquire the target 25 and still be close to the anticipated course of said target but well ahead of it. This attack position of the torpedo and the position of the firing vessel should, of course, both be far enough from target 25 so that the target may not be thereby. Once the torpedo is disposed at said attack position, its speed is reduced so that it runs slowly, quietly, and undetected in a direction substantially transverse to the probable path of the moving target ship. In other words, once the initial attack location is obtained, the torpedo may be properly aimed, a.g. for instance, has a frequency of 500 cycles per second and a wave length of about 10 feet, the value of D corresponds to about 1/10 of a cycle or about 36 (electrical) degrees in phase difference, which is the critical value of phase difference associated with the fixed lead angle of about 80°. A value of arc cosine 1/5 for α, when the torpedo course is perpendicular to the direction of the ship's travel, implies that the torpedo speed is approximately 1/5 the speed of the ship. Such parameters, of course, should not be considered as limiting, but they extensively produce satisfactory operation in the preferred embodiment of the invention disclosed herewith.

As a specific example of a typical operational procedure, if the distance between the transducers is 5 feet and angle α is set to be arc cosine 1/5 (about 80°), the distance D is then about 1/5 of 5 or 1 foot. If the received signal is for length of 10 feet, the value of D corresponds to about 1/10 of a cycle or about 36 (electrical) degrees in phase difference, which is the critical value of phase difference associated with the fixed lead angle of about 80°. A value of arc cosine 1/5 for α, when the torpedo course is perpendicular to the direction of the ship's travel, implies that the torpedo speed is approximately 1/5 the speed of the ship. Such parameters, of course, should not be considered as limiting, but they extensively produce satisfactory operation in the preferred embodiment of the invention disclosed herewith.

Consequently, as a result of the aforementioned phase differential measurements and concomitant processing thereof in the target bearing deviation system 18, the proper input signals are applied to motor speed and reversing controller 16 to cause motor 21 to drive torpedo screws 22 at just the right speed to automatically keep angle a substantially constant and torpedo 14 on a collision course with ship 25.

As may readily be seen, homing by fixed course direction and speed control as speeds depends upon having said course direction crossing or intersecting the path of the target ship, and of course, the nearer to the perpendicular thereof, the better. But, depending on the operational circumstances and the allowable torpedo speed, the subject speed-control method of homing on a target ship is practicable over a relatively wide range of angles between the ship and torpedo travel directions or relative bearing angles.

The operation illustrated in FIG. 3 may occur in event that the torpedo passes under the ship for some reason or another (such as might occur if proximity fuze operation being employed or is about to hit the ship (if a contact detonator is being employed). For purpose of analysis, if it is assumed that the course of the ship' noise is concentrated at a point 29 near the stern thereof, the value of the lead angle α will influence the position along the length of the ship at which the torpedo will hit. If, for some uncontrollable reason, the torpedo happens to miss and go across the bow, it will then quickly detect a large increase in the relative bearing angle of the ship. Upon such occurrence, the target bearing deviation and motor speed and reversing controller assembly reverses motor 21 and screws 22, thereby causing the torpedo to back up and probably back into the target ship to effect destruction thereof.
minimum of risk to all of the friendly combative elements involved.

All of the components represented in block form in foregoing disclosure are well known and conventional per se. Hence, it should be understood that it is their unique arrangement and interaction that produces the method and means constituting this invention.

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

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.

What is claimed is:

1. A method of guiding a torpedo along a collision course with a moving target ship comprising the steps of:
   a. guiding a torpedo to a position near to and toward the predicted path of a moving target ship but far enough from said ship as not to be detected thereby,
   b. disabling the guidance system which positioned said torpedo at the aforesaid position near the predicted path of a moving target ship,
   c. enabling a homing guidance system in said torpedo,
   d. acquiring said moving target with said enabled homing guidance system, and
   e. adjusting the speed of said torpedo with said homing guidance system in such manner as to effect a collision course with said moving target ship.

2. The method of claim 1 further characterized by the step of maintaining a substantially constant relative bearing angle with said moving target ship while the aforesaid torpedo speed is being adjusted.

3. The method of claim 2 further characterized by the step of causing said torpedo to back up in event said relative bearing angle rapidly increases at a predetermined rate.

4. In a guided torpedo,
   a. means for determining the deviation of a torpedo from a predetermined relative bearing with a moving target ship,
   b. means connected to deviation determining means for controlling the speed of said torpedo in such manner as to maintain said predetermined relative bearing substantially constant.

5. The device of claim 4 wherein said means for determining the deviation of a torpedo from a predetermined relative bearing with a moving target ship includes,
   a. a first transducer disposed on the side of said torpedo adjacent said ship,
   b. a second transducer spatially disposed in a longitudinal direction from said first transducer and likewise on the side of a said torpedo adjacent said ship, and
   c. a target bearing deviation system coupled to the output of said first and second transducers.

6. The invention according to claim 4 further characterized by means connected to said deviation determining means for timely enabling and disabling same.

7. A torpedo guidance system comprising in combination, means for guiding a torpedo to a predetermined position with a predetermined attitude, means for acquiring a moving target ship, means for driving said torpedo independent of the aforesaid torpedo guiding means, means interconnecting said acquiring means and said driving means for varying the speed of said torpedo in such manner as to maintain a collision course with the moving target ship acquired by said acquiring means.

8. A torpedo guidance system comprising in combination, a firing vessel control, a guidance system having an input and a pair of outputs, a rudder controller connected to the output of said guidance system, a torpedo rudder effectively coupled to said rudder controller, a motor speed and reversing controller coupled to the other output of said guidance system, a reversible direct current motor connected to the output of said motor speed and reversing controller, torpedo screws effectively coupled to said reversible direct current motor, and means interconnecting said firing vessel control and said motor speed and reversing controller for acquiring and homing on a moving target vessel.

9. The device of claim 8 wherein said means interconnecting said firing vessel control and said motor speed and reversing controller for acquiring and homing on a moving target vessel comprises,
   a. a target bearing deviation system, and
   b. a plurality of spatially disposed transducers respectively connected to a like plurality of inputs to said target bearing deviation system.

10. The device of claim 9 wherein said target vessel is a moving ship.

11. The device of claim 9 wherein said plurality of spatially disposed transducers is a pair of electroacoustical transducers spatially disposed along the longitudinal axis of a torpedo and on the side thereof adjacent the aforesaid moving target vessel.