A submarine launched missile having a solid propellant rocket motor portion and a weapon portion is adapted for guidance from the water through the air and after motor burn out, followed by motor and weapon separation, aerodynamic steering of the weapon to the target point by a terminal guidance system for control of movable surfaces on the weapon.

2 Claims, 10 Drawing Figures
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SHORT RANGE GUIDED MISSILE

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.

The present invention relates to guided missiles and particularly to an improved guided missile, for use principally in antisubmarine warfare, which is launchable from the conventional torpedo tubes of an attack submarine.

A scheme for antisubmarine warfare which has previously been described in the copending patent application of Roland G. Daudelin et al., Ser. No. 770,235, filed Oct. 23, 1958, for Method and Apparatus for Destroying Submarines. In this scheme, a missile having an anti-submarine warhead is launched from the torpedo tubes of a submerged attack submarine and is guided out of the water into the air and then back into the water in the vicinity of the target. This missile has a solid propellant rocket motor portion and a weapon portion which are separable after the motor burns out, the weapon portion thereafter being aerodynamically steered to the target point by means of a terminal guidance system and movable control surfaces thereon.

It is suggested in the Daudelin application that either a depth bomb or a conventional homing torpedo might be employed as the warhead. The restrictions of a conventional torpedo tube limit the size of the missile, particularly its length, and when the torpedo was employed, it was found that the missile was too long.

By employing, among other things, a guidance and control technique in which the weapon portion flies wholly ballistically after the boost phase is terminated, the weapon portion itself is greatly simplified. Terminal guidance equipment and the auxiliary power unit as used to operate the moveable control surfaces are eliminated, consequently shortening the weapon portion and making more space available for the motor. It is noted that the specific details of the guidance mechanism which enables this ballistic flight to be carried out accurately are not part of the present invention but have been previously described in a copending patent application by C. W. Kissinger, Ser. No. 297,468, filed July 24, 1963, for Method and Apparatus for Compensating a Ballistic Missile for Atmospheric Perturbations. This guidance system measures the deviations or perturbations of the missile due to wind effects during the boost phase of the trajectory and causes the missile to execute a maneuver just prior to burnout of the motor which compensates for the wind effects encountered on the way up and those anticipated on the way down, assuming that the winds will be the same in both portions of the trajectory.

The guidance method as described is not without its own inherent disadvantages, however, principal among which is the necessity to keep the maximum altitude low to increase the proportion of the trajectory in which the motor and guidance are operative, i.e., to insure that the weapon will not go higher after burnout into a zone in which the winds were not measured. Such a low trajectory requires more power from the motor to achieve the same range as in the higher conventional trajectory, and this factor dictates that the entire missile be of minimum overall weight and utilize the maximum of motor efficiency from the volume available.

Accordingly, it is a principal object of the present invention to provide a highly accurate short range guided missile, useable in antisubmarine warfare, for delivery of a homing torpedo to a target area in a manner to effect a high kill probability.

It is a further object of the invention to provide an improved missile for antisubmarine warfare which is less complex and relatively more efficient than previous missiles designed for the same purpose while retaining substantially the same overall effectiveness with respect to a target as prior art missiles.

Other objects and advantages of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings, wherein:

FIG. 1 is a perspective view showing the overall configuration of the present missile;
FIG. 2a is an elevational view, partly in section, of the rocket motor of the present missile;
FIG. 2b is an elevational view, partly in section of the weapon portion of the missile showing a torpedo in place therein;
FIG. 3 is a sectional view taken on line 3—3 of FIG. 2b, with the torpedo removed for clarity;
FIG. 4 is a rear view of the missile with the blow-off cover removed, showing the arrangement of the thrust nozzles and the drive-out fin stabilizers;
FIG. 5 is a sectional view of the motor taken on line 5—5 of FIG. 2a;
FIG. 6 is a detailed cross-section through one of the electrical conduits inside the motor;
FIG. 7 is a block diagram of the guidance and control equipment used in the present missile;
FIG. 8a is a diagrammatic view of the vertical trace of the trajectory here employed; and
FIG. 8b is a horizontal trace similar to FIG. 8a and showing in addition a nominal no wind trace and a trace wherein wind is present but no compensation is made.

The overall configuration of the present missile is shown in FIG. 1, wherein the rocket motor portion is designated at A and the weapon portion is at B. These portions are releasably secured together in known manner by explosive bolts (not shown) which are actuated to jettison the motor when its fuel supply is exhausted, in a manner similar to that disclosed in the aforementioned Daudelin application. After jettison of the motor, the weapon comprising a torpedo and an airframe attached thereto flies ballistically to the target point as will appear more fully hereinafter.

The solid propellant rocket motor is shown in detail in FIGS. 2a, 4, 5 and 6. Referring first to FIG. 2a, the motor is comprised of an elongated cylindrical casing 10 which is adapted at one end 12 to be connected to the weapon portion. Spaced inwardly from end 12 is a fixed bulkhead 14 which defines a space in which the guidance apparatus and necessary power supplies, generally shown at 16, are housed. Another fixed bulkhead 18 is spaced inwardly from the opposite end 20 of the cylindrical casing and defines, with bulkhead 14, a propellant chamber 22. Propellant 24 is loaded into chamber 22 through an opening in bulkhead 14 and is molded in the known manner to leave a central passage 26 of star-shaped cross-section (See FIG. 5). The opening in the bulkhead is then closed by a plug 27. Passages 28, only one of which appears in FIG. 2a, communicate...
with the thrust nozzles 40 and a passage 30 communicates with an auxiliary power unit 32.

Provision is made for direct thrust reversal to slow the motor after separation from the weapon. For this purpose, nozzle ports 34 are provided adjacent the forward end of the motor. These ports communicate directly with the propellant chamber by virtue of passages 36 and are directed at least partially in the forward direction. Ports 34 are normally closed by a band 38 which encircles the casing 10 and is held by an explosive release mechanism (not shown). At the time of separation, the explosive release mechanism is actuated to remove the band 38 from blocking relation to ports 34 and to thereby permit gases to exhaust through ports 34 to impart a reverse thrust to the motor.

The auxiliary power unit 32 of this missile is described in the copending application of Samuel H. Humphrey, Ser. No. 193,078, filed June 1, 1962, which matured into U.S. Pat. No. 3,136,250 on June 9, 1964. The unit 33 is shown in FIGS. 2a and 4 as comprising a hydraulic cylinder 42 having a piston 44 moveable therein by gases from the rocket in order to provide pressurized hydraulic fluid to operate the thrust vectoring nozzles 40 and the drive-out type fins 46. Nozzles 40 advantageously are three in number and as illustrated are spaced at 120° intervals about the longitudinal axis of the missile, each nozzle being provided with a moveable skirt portion 48 which is journaled for limited pivotal movement about a radial axis. Nozzle actuating and control units 50 are powered by the hydraulic cylinder 42 and controlled by the guidance system to provide thrust vectoring to steer the missile through the compensation maneuver.

Also powered by the hydraulic cylinder 42 are the three drive-out control fins 46 which are normally kept retracted within cylindrical casing 10 to accommodate the missile to the torpedo tube. Upon ignition of the motor, these fins move to their extended positions to stabilize the missile in the underwater portion of its flight.

While the missile is in storage, and up to the moment of ignition of the motor, the rear end of the motor is closed by a blow-off cover 51, which also serves as a support for two igniters 53 (only one of which appears in FIG. 2a) and a delay mechanism 55 thereof. The motor in the Daudelin missile is ignited from the forward end, and in distinction therefrom the placement of the igniter components for the instant missile on the blow-off cover 51 serves to free space in the motor for additional propellant. After the motor has ignited, elements 53 and 55 are no longer of utility and it is therefore expedient to cast them off with the blow-off cover 51. Two igniters are used to provide increased reliability. In order to aid in propagating the ignition upstream against the resistance of the gases in this motor, a coating of initiating material may be placed on the propellant surface.

Another distinction in the instant missile over the prior type missiles resides in the construction of the electrical cable conduits which extend from the guidance and power supply section 16 at the front of the motor to the control elements 50 in the rear. These conduits are designated at 52 and appear in FIGS. 5 and 6. They are attached to the inside of casing 10 by suitable welds 54. Conduits 52 are flattened as shown at 56 to conform to the curvature of casing 10. This construction insures that there will be no space for propellant to get between the conduit and the casing and be pinched therebetween when pressure builds up in the motor. The continuous envelope provided by the flattened conduits is preferred over semicylindrical or channel shaped conduits in that this configuration reduces the possibility of leaks.

The weapon portion of the missile is shown in FIGS. 2b and 3. The weapon portion and the actual warhead thereof is of a conventional nature for a homing type torpedo, which is adapted for air flight by providing an aerodynamic nose fairing 60 at its forward end and an airframe generally designated at 62 at its after end. Airframe 62 is comprised of a cylindrical shell 64 which is constructed of four clamshell sections 66 (FIG. 3) which are connected together by clamps 68. Cylindrical shell 64 is connected to the torpedo by a fairing band 70 which is releasable by means of an explosive clamp mechanism 72, which is actuated in response to the weapon's entry into the water at the end of its air flight. The breakaway clamshell design provides for a trouble-free separation of the torpedo from the airframe at the time of water entry.

Four broad, hollow fins 74 are connected in any suitable manner to the exterior of shell 64 to provide aerodynamic stability for the weapon. By making the fins broad and hollow, such components as arming and fuzing elements 76 may be conveniently housed therein. Electrical connections are afforded by leads 78 and breakaway connectors 80 between the airframe and the motor and 82 between the airframe and the torpedo.

Housed within the shell 64 at the rear thereof is a parachute pack 84 having a parachute 86 therein. The parachute is released and deployed by conventional means actuated by a barometric device 88 when the weapon reaches a predetermined altitude above the desired point of water entry. As shown, barometric device 88 may be housed in one of the fins 74.

Turning now to the guidance system used in the present missile, attention is directed to FIG. 7. As stated above, the details of this system are described by Kisinger in application, Ser. No. 297,468. For purposes of the present disclosure, the system has been shown in broad block diagram form but the construction should be readily apparent to those skilled in the art. Essentially, the system consists of an inertial reference 100 capable of providing outputs representative, among other things, of the orthogonal x, y and z accelerations \( \dot{x} \), \( \dot{y} \) and \( \dot{z} \), respectively. These outputs are supplied to a navigational computer section 102 in which well known type components perform two integrations of the acceleration signals to provide information indicative of displacements \( x \), \( y \) and \( z \) and velocities \( \dot{x} \), \( \dot{y} \) and \( \dot{z} \). This latter information is fed to a guidance computer section 104 in which control laws are developed for the control elements 50 connected to the thrust vectoring nozzles 40. The computer computation is based on an assumption that the causes of the perturbations of the missile will be the same in the ballistic phase of the flight as they are during the boost phase, and the computer 104 therefore provides a double correction to inject the weapon into a trajectory which will compensate for the total error. By virtue of suitable programming, this correction is applied just prior to burnout of the motor and causes the missile to make a correction maneuver at this time.
OPERATION

Attention is now directed to FIGS. 8a and 8b for assistance in understanding the sequence of operation of the present missile. The x-z plane is taken as the surface of the water and the x-y plane is chosen as the vertical plane containing the bearing direction from the attack submarine $S$ to the desired point of water entry $a$. The wind profile is shown in FIG. 8b as a series of wind velocity vectors $V_w$ extending over the distance of the air flight of the missile. For purposes of explanation, the wind velocity is shown to increase from a low value at sea level to a maximum at the point of maximum altitude of the missile, although the actual situation may be different.

Prior to launch, the missile is located in a torpedo tube of the attack submarine $S$ where it is connected in known manner to receive target range and bearing data from the fire control system of submarine $S$. At the desired time, the missile is propelled out of the torpedo tube by a charge of compressed air, also in known manner, and after a suitable delay the igniters 53 are actuated to start the motor. As pressure builds in the motor, the blow-off cover 51 is cast off and the drive out fins 46 are caused to be extended to stabilize the missile in the water. The missile is then steered to the point of water exit $b$.

Dashed line $b-a$ in FIG. 8b represents a nominal trace which the missile would follow in the absence of wind. The presence of wind, however, causes the missile to be blown off the nominal trace, and it is assumed here for purposes of explanation that no compensation for wind is made, the missile will fly to point $a'$. From point $b$ to point $c$ in the flight, the guidance system detects the magnitude of the effect of wind as noted above. At point $c$ the correction maneuver begins, and the missile is turned in a direction which will compensate for the assumed similar winds during the ballistic portion of the flight. Burnout and separation of the motor occurs at point $d$ which is chosen to be as close as possible to the point of maximum altitude $e$. The weapon portion then flies ballistically to the vicinity of point $a$.

When the weapon descends to a predetermined altitude, the barometric parachute release device operates to deploy the parachute and lower the torpedo gently into the water. Airframe 62 is jettisoned when the weapon enters the water; the torpedo motor is started; and finally, the torpedo seeks out and destroys its target.

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 as specifically described.

What is claimed is:

1. A short range guided missile comprising:
   a. a rocket motor;
   b. a ballistic homing torpedo weapon detachably connected to said rocket motor;
   c. a guidance system housed within said rocket motor, control means responsive to said guidance system for steering said rocket,
   d. means for separating said rocket motor from said weapon,
   e. means in said guidance system for determining the magnitude of the effects of winds on said missile, and
   f. means responsive to said measuring means for actuating said control means to inject said weapon into a ballistic trajectory in a manner to compensate for both said wind effects and anticipated equal wind effects subsequently encountered during ballistic flight of said missile, means for adapting said homing torpedo weapon for air flight comprising an aerodynamic nose fairing attached to the forward end of said torpedo weapon, an airframe releasably attached to the after end portion of said torpedo weapon, comprising, a cylindrical shell attached coaxially to said torpedo weapon, said shell being adapted to be connected to said rocket motor, a parachute pack contained within said shell having a parachute therein, a barometric device for deploying said parachute when said weapon reaches a predetermined altitude, and aerodynamic fins on said shell, said fins being hollow and said barometric device being housed within one of said fins.

2. A missile as defined in claim 1, wherein arming and fuzing means for said torpedo weapon are housed within said hollow fins.