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LAUNCH TUBE WITH ADJUSTABLE PLENUM

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT (1) MICHAEL W. WILLIAMS, (2) GARY R. BERLAM, (3) NICHOLAS BITSAKIS, (4) JAMES A. LILLEY, and (5) BRENDA BRENNEN MACLEOD, citizens of the United States of America, employees of the United States Government and residents of (1) Portsmouth, County of Newport, State of Rhode Island, (2) Concord, County of Middlesex, Commonwealth of Massachusetts, (3) Seekonk, County of Bristol, Commonwealth of Massachusetts, (4) Portsmouth, County of Newport, State of Rhode Island and (5) Nashua, County of Hillsborough, State of New Hampshire, have invented certain new and useful improvements entitled as set forth above of which the following is a specification:

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3 LAUNCH TUBE WITH ADJUSTABLE PLENUM

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5 STATEMENT OF GOVERNMENT INTEREST

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

10

11 BACKGROUND OF THE INVENTION

12 (1) Field of the Invention

13 This invention generally relates to a launch tube assembly
14 with an adjustable plenum volume.

15 More particularly, the invention relates to an adjustable
16 length launch tube assembly with an adjustable plenum volume
17 which assures that countermeasures launched from a launch tube
18 have a predetermined acceleration.

19 (2) Description of the Prior Art

20 Current externally housed submarine countermeasures are
21 launched by way of gas generators. The generated gas pressure
22 builds up behind the ram plate and countermeasure until there is
23 enough pressure to shear pins holding a muzzle cap in place.
24 This then allows the countermeasure to move through the launch
25 tube and exit. The current gas generator imparts acceleration to

1 the device on the order of 90 g's. A redesign of the gas
2 generator is expected to impart accelerations on the order of 50
3 g's.

4 The following patents, for example, disclose gas generation
5 in launch systems, but do not disclose an adjustable length
6 launch tube which in turn creates a predetermined initial plenum
7 volume.

8 U.S. Patent No. 5,819,526 to Jackson et al.;

9 U.S. Patent No. 5,837,919 to Yagla et al.;

10 U.S. Patent No. 5,942,712 to Mello;

11 U.S. Patent No. 5,984,635 to Keller;

12 U.S. Patent No. 6,044,746 to Gendre et al;

13 U.S. Patent No. 6,079,310 to Yagla et al.;

14 U.S. Patent No. 6,230,629 to Doctor et al; and

15 U.S. Patent No. 5,302,076 to Bredy.

16 Specifically, Jackson et al. discloses a lower power arcjet
17 propellant feed system for delivering propellant to the low power
18 arcjet. The low power arcjet propellant feed system includes a
19 liquid propellant storage chamber for storing a liquid
20 propellant. A gas generator in communication with the liquid
21 propellant storage chamber generates a gaseous propellant upon
22 receipt of the liquid propellant from the liquid propellant
23 storage chamber. A gas plenum in communication with the gas
24 generator accumulates the gaseous propellant for the gas
25 generator up to a desired pressure. Actively controllable valves

1 actively control the flow of the liquid propellant into the gas
2 generator and actively control the flow of the resultant gaseous
3 propellant out of the gas generator and into the gas plenum up to
4 the desired pressure. A substantially continuous and stable low
5 flow rate of gaseous propellant is then delivered to the low
6 power arcjet.

7 The patent to Yagla et al. '919 discloses a launcher having
8 means for directing and concentrically spreading, as well as
9 dispersing, exhaust gases created by an internal combustion of an
10 object, such as a missile, that is operatively launchable
11 therefrom. The concentric duct provides the directing, spreading
12 and dispersing means and cooperates with a cup having a means to
13 arrange a port in operative relationship with an exhaust outlet
14 of the object being launched. The cup which mates with the
15 concentric duct has one of its ends open to the ambient so that
16 the exhaust gases are lead into and out of the concentric duct so
17 as to be concentrically dispersed into the atmosphere.

18 Mello discloses a submarine signal launcher for preventing
19 pinched control wires therein. The submarine signal launcher
20 includes a gas generator, an acoustic device countermeasure, a
21 launch tube for housing the gas generator and the countermeasure,
22 and a ram plate positioned between the gas generator and the
23 countermeasure. A status cable is connected to the
24 countermeasure and intermediately threaded through the ram plate
25 and joined to the gas generator. A collapsible tube is connected

1 to the ram plate and the gas generator. The status cable is
2 confined within the collapsible tube. Securing members are
3 formed on opposing ends of the collapsible tube for securing the
4 collapsible tube to the ram plate and the gas generator, wherein
5 upon assembly of the gas generator with the ram plate and the
6 countermeasure within the launch tube, the collapsible tube will
7 protect the cable from being pinched between joined ends of the
8 ram plate and the gas generator.

9 Keller discloses a helicopter aircraft with an upper hollow
10 center circular plenum in gaseous communication with a plurality
11 of hollow hinged attached rotor blades. Below the plenum and in
12 gaseous communication with it are two fan jet engines whose
13 gaseous output can be inputted to the plenum and their attached
14 hollow rotor blades through an operator controlled valve system.
15 This same valve system can be adjusted to completely or partially
16 by-pass the plenum and discharge the jet engines' gas to a common
17 rear rudder located on the aircraft to provide directional
18 control to the aircraft when in flight. The plenum is shaped
19 lenticular in cross section similar to an airplane wing to
20 provide a lifting body when the helicopter is in forward flight.

21 The patent to Gendre et al. discloses a projectile
22 propulsion assembly of the type comprising a chamber housing a
23 pressure source. The chamber which houses the pressure source
24 communicates with at least one pipe placed inside the launch tube

1 and having bores distributed along its length so as to be
2 released in succession during ejection of the projectile.

3 Yagla et al. '310 discloses a launcher having means for
4 directing and concentrically spreading, as well as dispersing,
5 exhaust gases created by an internal combustion of an object,
6 such as a missile, that is operatively launchable therefrom. The
7 concentric duct provides the directing, spreading and dispersing
8 means and cooperates with a cup having means to arrange a port in
9 operative relationship with an exhaust outlet of the object being
10 launched. The cup which mates with the concentric duct has one
11 of its ends open to the ambient so that the exhaust gases are
12 lead into and out of the concentric duct so as to be
13 concentrically dispersed into the atmosphere.

14 The patent to Doctor et al. discloses an IR radiating decoy
15 for an IR seeking anti-ship missile (ASM) and includes a
16 propulsion section, safe and arming section, gas generator
17 section, fuel tank section, and flight stabilization section to
18 ignite and continuously maintain an IR plume for decoying the ASM
19 away from the targeted ship. The IR radiating decoy ignites the
20 IR plume immediately when the decoy reaches a safe separation
21 distance from the targeted ship. The IR plume continues to be
22 emitted as the decoy flies away, as it lands on the water, and
23 while it floats upon the water until all the fuel is used from
24 the fuel tank. The fuel can be changed to change the signature

1 of the IR plume so that different ASM missiles can be drawn away
2 from the ship.

3 Bredy discloses a four stroke combustion engine and method
4 of operation of use and control. The engine includes a
5 combustion chamber with an intake manifold coupled to the
6 combustion chamber. A one-way valve is located within the intake
7 manifold. The engine includes an intake valve for modulating the
8 flow of a fuel-air mixture into and out of the combustion
9 chamber. The engine preferably employs a fixed, late closing
10 intake valve. A plenum chamber is located in the intake
11 manifold. The plenum chamber is located downstream of the one-
12 way valve and upstream of the intake valve. During the
13 compression stroke of the engine, a pressurized charge of the
14 fuel-air mixture is stored within the manifold and plenum. The
15 amount of the fuel-air mixture stored within the plenum is
16 controlled by adjusting the volume of the plenum, or,
17 alternatively, a plenum valve is used to regulate the amount of
18 fuel-air mixture entering/exiting a fixed volume plenum.

19 It should be understood that the present invention would in
20 fact enhance the functionality of the above patents by providing
21 an adjustable volume plenum that reduces peak acceleration on the
22 countermeasure device being launched from the launch tube
23 assembly.

SUMMARY OF THE INVENTION

Therefore it is an object of this invention to provide a launch tube assembly having a controllable peak acceleration.

A still further object of the invention is to provide a launch tube assembly in which a forward launch tube portion is longitudinally adjustable relative to a sleeve member connected to the aft launch tube portion, by a threaded connection therebetween.

Yet another object of this invention is to provide a launch tube assembly which incorporates existing launch tube structure to adjust a plenum volume suitable for launching a countermeasure device at a predetermined acceleration.

In accordance with one aspect of this invention, there is provided a launch tube assembly including an aft launch tube portion, a forward launch tube portion, and a transfer sleeve having a first end fixed to and adjacent the forward end of said aft launch tube portion and a second end adjustably receiving the forward launch tube portion. A forward end of the aft launch tube portion faces a rearward end of the forward launch tube portion within the transfer sleeve. An adjustable plenum is present having a volume within the transfer sleeve defined by an adjusted distance between the facing ends of aft and forward launch tube portions. An end cap is pinned to a forward end of the forward launch tube portion, a gas generator housed in the aft launch tube portion, and a countermeasure device is housed in

1 the forward launch tube portion. An adjustably selected volume
2 of the plenum is such that a gas generated by the gas generator
3 will enable propulsion of the countermeasure device at a
4 predetermined acceleration from the forward launch tube portion.

6 BRIEF DESCRIPTION OF THE DRAWINGS

7 The appended claims particularly point out and distinctly
8 claim the subject matter of this invention. The various objects,
9 advantages and novel features of this invention will be more
10 fully apparent from a reading of the following detailed
11 description in conjunction with the accompanying drawings in
12 which like reference numerals refer to like parts, and in which:

13 FIG. is a side sectional view of launch tube assembly
14 according to a preferred embodiment of the present invention.

16 DESCRIPTION OF THE PREFERRED EMBODIMENT

17 In general, the present invention is directed to an
18 adjustable launch tube assembly as generally shown at 10 in the
19 FIG.

20 The defining structure of the adjustable launch tube 10
21 includes an aft launch tube portion 12, a forward launch tube
22 portion 14, and a transfer sleeve 16.

23 The aft launch tube portion 12 is typically cylindrical in
24 section, and has a closed end 18 and an open end 20. An interior
25 22 of the aft launch tube portion 12 houses a gas generator 24.

1 The forward launch tube 14 includes an open end 26 aligned
2 with and facing the open end 20 of the aft launch tube portion 12
3 and a forward end 28 into which a muzzle cap 30 is secured by a
4 plurality of shear pins 32. An outer surface 34 of the forward
5 launch tube 14 includes recessed grooves 36 adjacent the open end
6 26 thereof and a threaded portion 38 intermediate the open 26 and
7 forward 28 ends thereof. An interior 40 of the forward launch
8 tube 14 houses a ram plate 42 and a countermeasure device 44,
9 with the countermeasure device 44 abutting the muzzle cap 30.

10 The transfer sleeve 16 has an inner surface 46 corresponding
11 in dimension to an outer surface 48 of the aft launch tube 12.
12 As previously indicated, it is preferable that the aft launch
13 tube portion 12, forward launch tube portion 14, and transfer
14 sleeve 16 are circular in shape. The transfer sleeve 16 includes
15 a first end 50 fixed to said aft launch tube 12 and a second end
16 52.

17 The first end 50 of the transfer sleeve 16 is fixed by
18 welding or the like to the outer surface 48 of the aft launch
19 tube portion 12. The second end 52 of the transfer sleeve 16
20 includes an outwardly radial flange 54 having plural spaced
21 apertures 56 formed therein and therethrough.

22 A locking collar 58 includes a threaded inner annular
23 surface 60 and an outwardly radial flange 62 with plural spaced
24 apertures 64 formed therein. The inner surface 60 of the locking
25 collar 58 is threadably engageable with the outer threaded

1 surface 38 of the forward launch tube 14 and faces of the radial
2 flanges 54 and 62 are aligned such that the respective plural
3 apertures 56 and 64 thereof can be aligned. Plural bolts 66
4 inserted through corresponding ones of the plural aligned
5 apertures 54 and 64 secure the locking collar 58 to the radial
6 flange 62 and to the radial flange 54 of the transfer sleeve 16.

7 Sealing members 68, such as O-rings, are seated within the
8 recessed grooves 36 on the outer surface 34 of the forward launch
9 tube 14 in order to seal out any hydrostatic pressure between the
10 forward launch tube 14 and the transfer sleeve 16.

11 As an alternative, it should be noted that the interior
12 surface adjacent the first end 50 of the transfer sleeve 16 may
13 be threaded, and the exterior surface at the forward end 20 of
14 the aft launch tube portion 12 may be threaded as well. The
15 current version is for ease of assembly, and therefore, may be
16 varied.

17 A plenum 70 is defined in the interior of the transfer
18 sleeve 16 in the location between the open end 20 of the aft
19 launch tube portion 12 and the open end 26 of the forward launch
20 tube portion 14. The plenum 70 volume is selectively adjusted
21 according to the distance into the transfer sleeve 16 that the
22 forward launch tube portion 14 is threaded. The position of the
23 forward launch tube 14 provides a nearly maximum volume to the
24 plenum 70. In other words, if the forward launch tube portion 14
25 is such that the locking collar 58 is at an inner most end of the

1 threaded portion 38 thereon, then the plenum 70 is at a maximum
2 volume. Likewise, positioning the forward launch tube portion 14
3 within the transfer sleeve 16 to the point where an outermost end
4 of the threaded portion 38 thereof is engaged with the threaded
5 surface 60 of the locking collar 58 will provide a minimum volume
6 for the plenum 70.

7 In keeping with the structure described in connection with
8 the FIG., the basic operation of a countermeasure launcher is
9 that an electrical signal (not shown) is sent to the gas
10 generator 24 located within the aft launch tube portion 12 for
11 its activation. As gas is being generated, the volume between
12 the gas generator 24 and the ram plate 42 becomes pressurized to
13 a level where the compressive load being applied to the shear
14 pins 32 which hold the muzzle cap 30 in place, shear, and allow
15 movement of the countermeasure device 44. The continuation of
16 gas generation assures that the pressure behind the ram plate 42
17 is sufficient to move the countermeasure 44 completely out of the
18 forward launch tube portion 14.

19 The physical reason for the increased initial plenum volume
20 resulting in lower peak accelerations on the countermeasure 44
21 can be explained by the following relationships:

22
$$a_{CM} = \frac{\sum F_{CM}}{m_{CM}} \quad (1)$$

23
$$\sum F_{CM} \propto P_{plenum} - P_{sea}, \quad (2)$$

where P_{sea} is constant and friction and drag are assumed negligible (in the first 50msec where peak acceleration occurs).

$$P_{plenum} = \frac{m_{gas} RT}{V_{plenum}}, \quad (3)$$

where V_{plenum} is constant until shear pin failure.

$$\frac{dP_{plenum}}{dt} \propto \frac{1}{V_{plenum}} \cdot \frac{dm}{dt} \quad (4)$$

prior to shear pin failure, assuming R and T constant.

$$P_{plenum}|_{peak} \approx \left. \frac{dP_{plenum}}{dt} \right|_{t=shear} \Delta t|_{shear}^{peak} + P_{shear}, \quad (5)$$

where Δt to transient peak is a function of the fluid spring system and is not dependent on initial plenum volume.

The relationship shown in equation (4) is a key to the explanation. Since the mass flow rate (dm/dt) entering the plenum at shear pin failure is only slightly lower for a larger initial plenum volume, V_{plenum} , dominates. Equation (4) shows that the pressurization rate (dP/dt) of the plenum will be lower for a larger initial plenum volume. Equation (5) shows that the overshoot of the plenum pressure (beyond shear pressure) is proportional to the pressurization rate. Equations (1) and (2) link plenum pressure to countermeasure acceleration. In summary, the larger initial plenum volume reduces the initial pressurization rate, which reduces the plenum pressure overshoot (hence, reduces peak plenum pressure), which reduces peak countermeasure acceleration.

1 The launch tube 10 with the adjustable plenum 70 is
2 assembled by first welding the aft launch tube portion 12 to the
3 transfer sleeve 16. The forward launch tube portion 14 is then
4 inserted into the transfer piece 16 to the desired length. O-
5 rings 68 inserted in grooves 36 the forward launch tube portion
6 14 seal the launch tube against hydrostatic pressure. The
7 locking collar 58 is then screwed along the forward launch tube
8 portion 14 until it is both flush against the radial flange 54 at
9 the end of the transfer sleeve 16 and the bolt holes 56, 64 are
10 aligned between the transfer sleeve 16 and the locking collar 58,
11 respectively. Bolts 66 are then secured around the circumference
12 of the mated radial flanges 54, 62 to assure the entire assembly
13 will withstand the loads during the launch event.

14 A mathematical model of a countermeasure launch is then
15 exercised in order to determine the appropriate plenum volume
16 necessary to achieve the desired peak acceleration on the
17 countermeasure being launched. The volume is then converted into
18 an overall launch tube length, and the forward launch tube
19 portion 14 is moved in or out to achieve the desired length.
20 Note that it was decided to control overall length thread by
21 threading the forward launch tube portion 14 and the transfer
22 sleeve 16 due to the greater linear dimension control. Also, the
23 volume was made adjustable due to the uncertainties of the
24 computer models.

1 It should also be understood that materials are chosen that
2 can withstand the stresses from a launch impulse.

3 The present invention will allow current gas generators,
4 that typically impart acceleration peaks on countermeasures of
5 90-g's to mimic future gas generators that are designed to impart
6 peak accelerations of 50-g's on similar weighted devices.

7 In view of the above detailed description, it is anticipated
8 that the invention herein will have far reaching applications
9 other than those of a countermeasure launch tube.

10 This invention has been disclosed in terms of certain
11 embodiments. It will be apparent that many modifications can be
12 made to the disclosed apparatus without departing from the
13 invention. Therefore, it is the intent of the appended claims to
14 cover all such variations and modifications as come within the
15 true spirit and scope of this invention.

2

3 LAUNCH TUBE WITH ADJUSTABLE PLENUM

4

5 ABSTRACT OF THE DISCLOSURE

6 A launch tube assembly including an aft launch tube portion,
7 a forward launch tube portion, and a transfer sleeve having a
8 first end fixed to and adjacent the forward end of said aft
9 launch tube portion and a second end adjustably receiving the
10 forward launch tube portion. A forward end of the aft launch
11 tube portion faces a rearward end of the forward launch tube
12 portion within the transfer sleeve. An adjustable plenum is
13 present having a volume within the transfer sleeve defined by an
14 adjusted distance between the facing ends of aft and forward
15 launch tube portions. An end cap is pinned to a forward end of
16 the forward launch tube portion, a gas generator housed in the
17 aft launch tube portion, and a countermeasure device is housed in
18 the forward launch tube portion. An adjustably selected volume
19 of the plenum is such that a gas generated by the gas generator
20 will enable propulsion of the countermeasure device at a
21 predetermined acceleration from the forward launch tube portion.

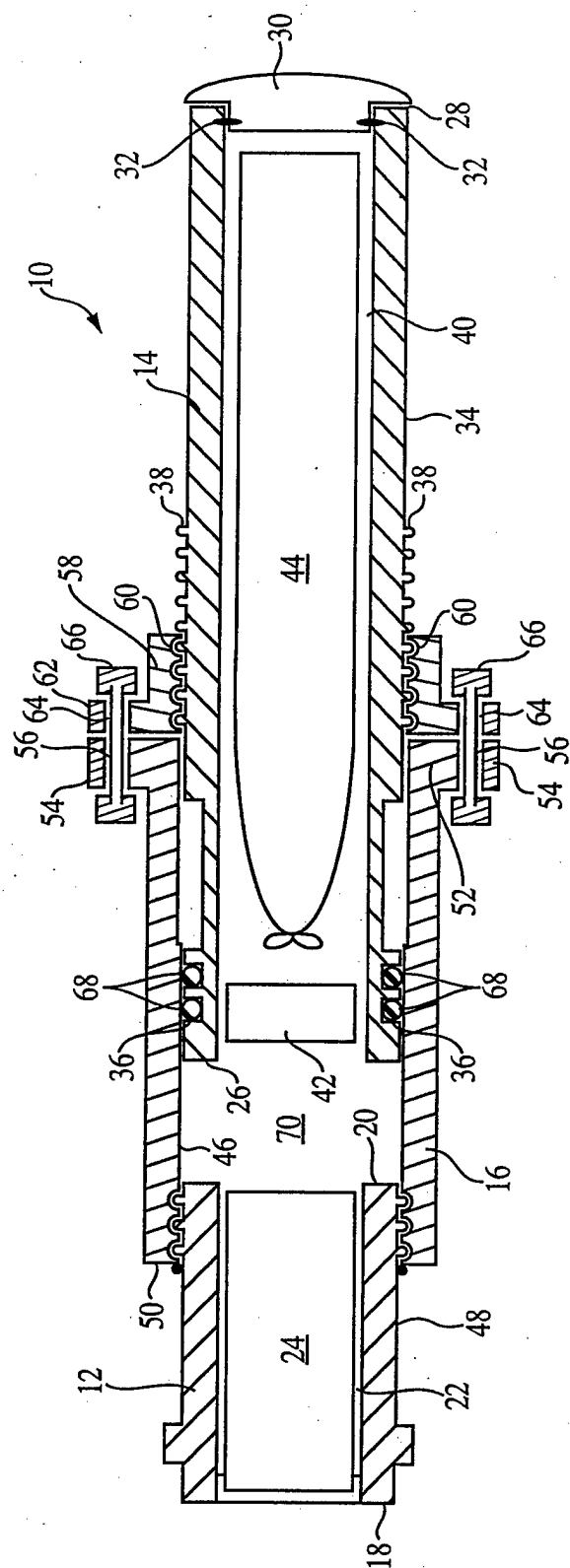


FIG.