May 14, 1968 E. D. SWANSON 3,382,832

TORPEDO DRAG REDUCTION APPARATUS

Filed Aug. 31, 1967 2 Sheets-Sheet 1

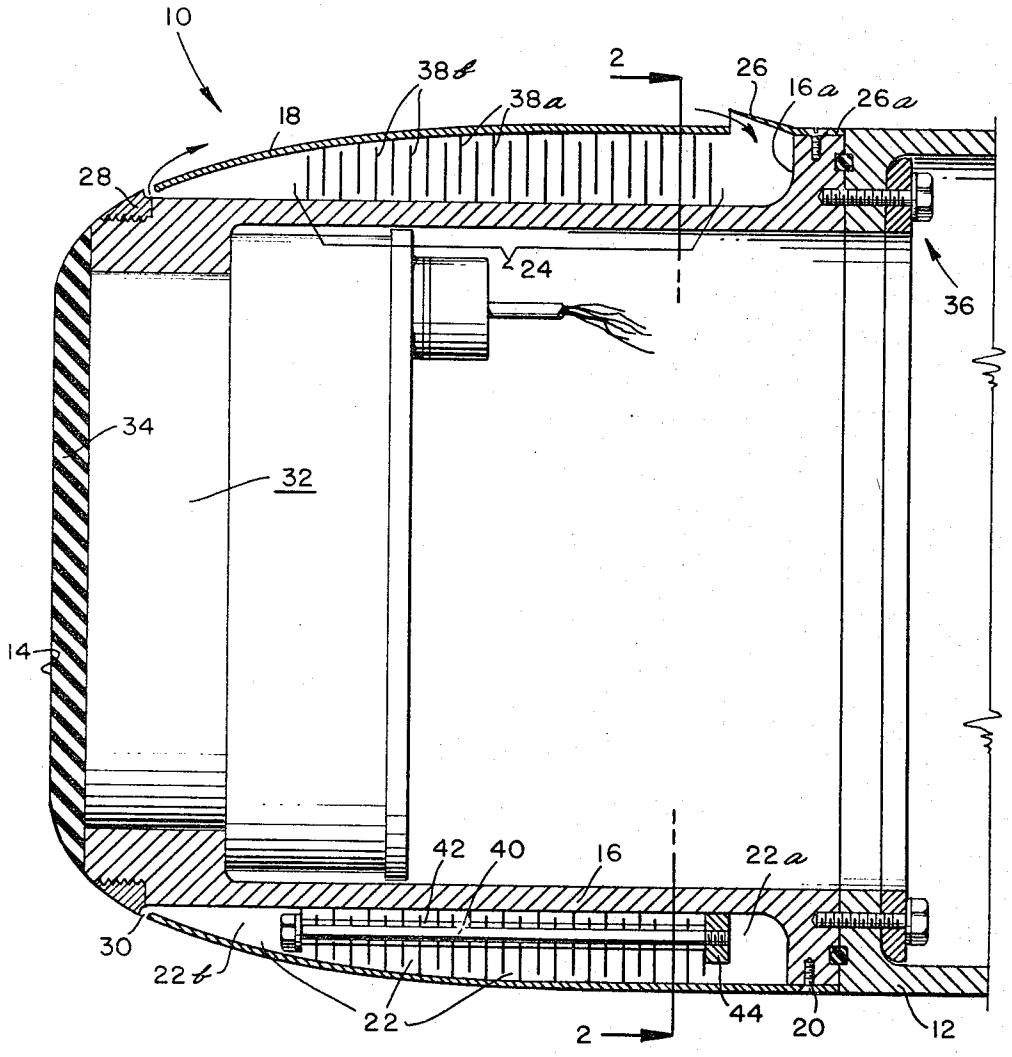


FIG. 1.

INVENTOR.
ERIC D. SWANSON

BY
MICHAEL F. OGLO
ROY MILLER
ATTORNEYS.

May 14, 1968 E. D. SWANSON 3,382,832

TORPEDO DRAG REDUCTION APPARATUS

Filed Aug. 31, 1967 2 Sheets-Sheet 2

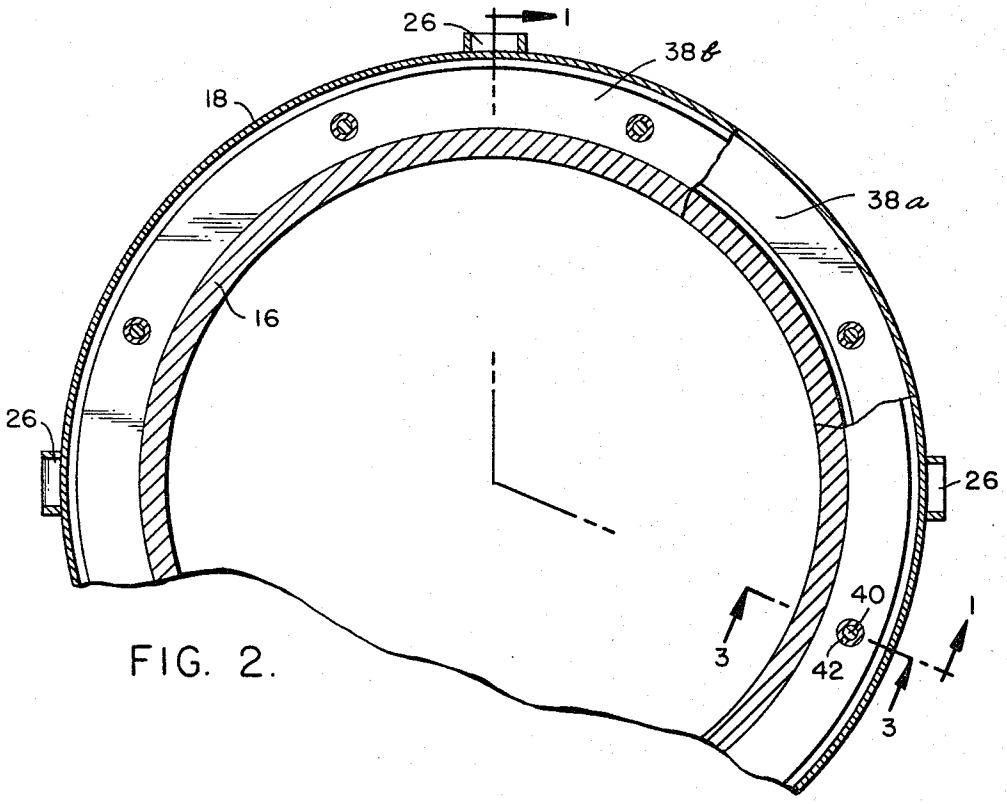


FIG. 2.

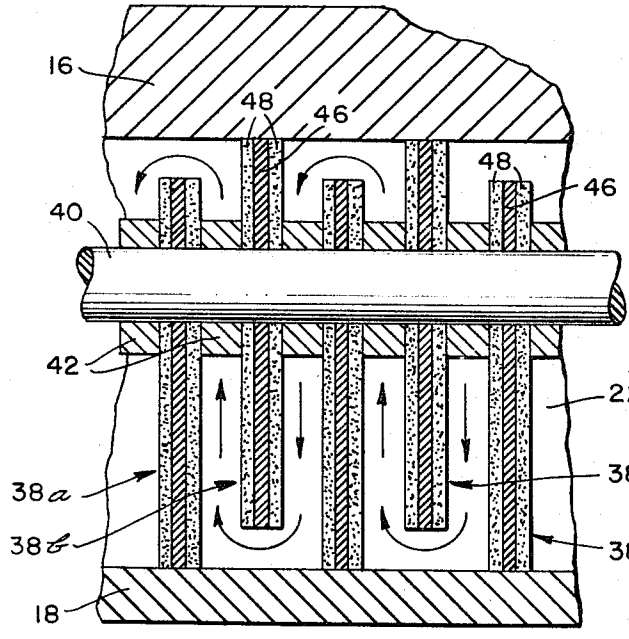


FIG. 3.

United States Patent Office

3,382,832

Patented May 14, 1968

3,382,832

TORPEDO DRAG REDUCTION APPARATUS

Eric D. Swanson, Arcadia, Calif., assignor to the United States of America as represented by the Secretary of the Navy

Filed Aug. 31, 1967, Ser. No. 665,685
6 Claims. (Cl. 114—20)

ABSTRACT OF THE DISCLOSURE

Sheets of an ablative and water soluble material containing a drag reducing polymer agent are mounted on a labyrinth of baffles in an annular cavity underneath the nose fairing of a torpedo. Ambient seawater, under ram pressure, is ingested by scoops and introduced into the rear end of the chamber. As the seawater circulates through the baffle labyrinth it dissolves the polymer agent contained in the ablative sheets. The front end of the annular chamber is communicated with the exterior of the surface of the torpedo hull by a circumferential slot which extends continuously about the torpedo. The solution of seawater and polymer resulting from the circulation of the water through the labyrinth issues forth through the slot into the boundary layer flow under the ram pressure.

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 improved torpedo apparatus of the type employing the introduction of an aqueous solution of certain polymer additives into the boundary layer flow about the torpedo. The polymer additives referred to, are of the type which have a high molecular weight and a long-chain molecular structure. Included among effective drag-reducing polymers are poly(ethylene oxide), and polyacrylamide.

It can be theoretically demonstrated that carrying a polymer additive within the torpedo, and continuously mixing and ejecting a solution of the additive and ingested seawater, compares favorably with increasing the amount of fuel or capacity of the propulsion engine. On a pound-for-pound basis, the approach of internally mixing the polymer-drag reduction solution offers a greater potential in increasing torpedo range, or alternatively increasing torpedo speed, than does the addition of incremental amounts of fuel or engine capacity. This theoretical potential has prompted various attempts to devise a practical apparatus to implement this approach.

In some of these cases, the resultant apparatuses have not been able to introduce the polymer agent into solution at a sufficient concentration and with a sufficient solution flow rate to be effective in reduction of drag. The serious difficulty which has confronted workers in these cases is the limitation imposed by the relatively low solution rates of the state-of-the-art forms of the polymer additive.

In another series of attempts, the polymer was added to ingested seawater by a continuous mixing device contained within the torpedo. While these efforts have been successful to a point, they have not resulted in practical use. One of the principal reasons behind this is the problem of packaging the mixer and dispenser necessary for such system. Present day torpedoes are principally intended for delivery from ship to target site by rocket propulsion or for delivery by aerial drop. This has resulted in compactness becoming of primary concern, with severe restriction of the weight and size of the torpedo and all its components. With these criteria, the space penalty imposed by systems of mixers and dispensers has been considered to outweigh their advantages.

A further aggravation is that incomplete hydration of the polymer in the solution negates the effectiveness of the solution in providing drag reduction. In some instances this has resulted in a need for residence-time chambers in connection with the mixing apparatus.

An object of this invention is to provide an improved drag reducing apparatus which may be conveniently packaged to make use of non-critical space in the nose fairing of a torpedo.

Another object is to provide apparatus in accordance with preceding objective which may be back-fitted to existing torpedoes by means of simple modifications to the torpedo's nose section.

A further object is to provide improved torpedo apparatus for dissolving drag reducing polymer into ingested seawater at concentrations and solution flow rates which are effective for drag reduction purposes.

A still further objective is to provide improved torpedo apparatus in accordance with the preceding objective which causes hydration of the polymer material without need for auxiliary residence time chambers.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a central section of the nose of a torpedo, certain parts being shown in side elevation;

FIG. 2 is an enlarged partial section taken along lines 2—2 of FIG. 1; and

FIG. 3 is an enlarged partial section taken along lines 3—3, FIG. 2.

Referring now to the drawing, and in particular to FIG. 1, drag reducing apparatus in accordance with the present invention is illustrated in connection with a nose section **10** of a blunt nosed anti-submarine warfare acoustic torpedo. Adjoining the rear end of nose section **10** is a main body section **12** (only a small portion of which is shown). Section **12** and the tail section (not shown) are entirely conventional.

Nose section **10** has the type of hydrodynamic shape consisting of a flat nose face **14** and a zone of gradual fairing for approximately 0.8 of the length of the nose section. The fairing depicted in the drawing is conventional and is known as the "cavitation bubble profile" shape. For the torpedo's intended purpose of attacking submerged submarines, it must have a pressure hull capability to withstand the high hydrostatic pressures at operating depths of present-day submarines. In nose section **10** there is an inner hull **16** which is the pressure hull, and an outer fairing wall **18** which forms the hydrodynamic surface. In main body section **12** there is only one hull which serves as both the pressure and hydrodynamic hull. The inner hull **16** is only slightly larger in diameter than the nose face **14**, and is provided with an outwardly projecting annular flange portion **16***a* at its rear end. The fairing wall **18** is fastened in place by means of a plurality of screws **20** which fasten the rear marginal edge of the

fairing wall to flange portion 16*a*. The construction is such that when the fairing wall is fastened in place, it merges with the exterior of main body section 12.

The space between fairing wall 18 and inner wall 16 forms an annular chamber 22. In length, chamber 22 extends from a short distance aft of nose face 14 to flange portion 16*a*. Its cross section is tapered in a forwardly direction corresponding to the contour of fairing wall 18. Within chamber 22 is disposed a baffle labyrinth 24 having its baffle faces coated with an ablative and water-soluble, polymer-type, drag reducing material. Details of the baffle labyrinth and the composition of its coating will be discussed at length in succeeding paragraphs. Four laterally projecting scoops 26, FIGS. 1 and 2, are provided at the rear end of chamber 22 in equiangularly spaced arrangement about the torpedo's circumference. Scoops are fastened in place by any suitable means such as screws 20 extending through a rear tab portion 26*a*. They serve to introduce seawater under ram pressure into an inlet zone 22*a* at the rear end of chamber 22. Ahead of wall 18, the fairing is formed by a small ring 28. The front edge of the fairing wall 18 is spaced slightly rearward from ring 28 forming a circumferential slot 30 which extends continuously about the torpedo nose. Slot 30 communicates an outlet zone 22*b* at the front end of chamber 22 with the exterior of the torpedo. If desired, a ring of drilled holes, aligned along a circumferential loci, may be substituted in place of the continuous slot. Conventional transducer acoustic apparatus 32, together with a conventional protective cap 34 of rubbery material, are affixed in the opening at the front end of inner wall 18. A suitable torpedo joint 36, in part formed by flange portion 16*a* of the inner wall, secures nose section 10 to main body section 12. In some instances, such as where the torpedo is to be fired from a launching tube, it may be desirable to construct scoops 26 as "pop-up" scoops, which are initially within the hull line of the torpedo and are actuated into their laterally extending position after water entry. Such constructions, may be initiated by a seawater switch, as is conventional with intake scoops for seawater batteries.

As best shown by FIG. 1 taken in conjunction with FIG. 3, the baffle labyrinth 24 comprises a stack of transverse spaced, annular baffle elements 38. These elements are held together by means of the plurality of longitudinal stacking rods 40 and spacer washers 42 between adjacent baffle elements. The rear end of each stacking rod 40 is threaded, and the stack is affixed in place by threaded engagement of these ends in tapped holes in lugs 44 affixed about the outside of inner wall 16. The individual baffle elements comprise two structural types consisting of a type 38*a* having its outer periphery in abutting contact with the fairing wall 18, and its inner periphery radially spaced from inner wall 16, and a type 38*b* having its inner periphery in abutting contact with inner wall 16, and its outer periphery radially spaced from the fairing wall. The baffle elements adjoining the contoured portion of fairing wall 18 are sized to correspond with its forward taper. The two different types of baffle elements, 38*a* and 38*b*, are alternately disposed in the stack. This provides a labyrinth through which the seawater must wind as it flows from inlet zone 22*a* to outlet zone 22*b*. This flow is indicated by arrows in FIG. 3.

As shown in FIG. 3, each baffle element 38 is of a sandwich construction with its center made of sheet aluminum 46 and ablative sheets 48 of a water soluble polymer-type drag reducing material bonded to each face. One example of a suitable ablative sheet material is the thermoplastic composition disclosed in the copending application of Alexander B. Arranaga entitled "Water-Soluble Poly(ethylene oxide) Plastic Compositions." Briefly, that composition comprises about 70%, by weight, of a finely powdered high molecular weight form of poly(ethylene oxide) plasticized by means of about 8% of a low molecular weight form of liquid polypropylene glycol, with a filler consisting of about 15% of finely powdered polyvinylpyrrolidone. Other minor amounts of wetting agent and stabilizers are also present. A typical stack structure using this material would contain 10–12 baffle elements per linear inch with an axial spacing of approximately .040 inch between adjacent elements. The radial gap between peripheries of the baffle elements and adjoining wall elements is also approximately .040 inch.

The operation of the present drag reducing apparatus will be readily apparent from the preceding description of the structure. Water taken in through scoop 26 is circulated through the baffle labyrinth and gradually ablates and dissolves the ablative sheets 48, placing the drag reducing polymer agent into solution. The solution is then ejected from annular slot 30 and swept back into the boundary layer by the ambient stream.

In the case of the given exemplary composition of ablative sheet 48, it has been found that the polymer drag reducing agent becomes partially hydrated before it is washed off of the baffles. As a result the polymer is hydrated to the desired degree as it flows from slot 30. However, in instances in which the ablative sheet material may not hydrate this rapidly, the invention may be modified by provision of a baffle labyrinth *without* ablative sheets at the front end of the chamber, to provide the necessary hydration residence-time.

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. In a torpedo, apparatus for producing an aqueous-polymer turbulent friction damping solution using ingested seawater as the solvent, said apparatus comprising:
   (a) said torpedo being of the type having a generally cylindrical hydrodynamic hull,
   (b) a longitudinally extending annular channel formed underneath said hull adjacent the nose end of the torpedo,
   (c) means for introducing ingested seawater into said annular channel at its rear end, and
   (d) an array of stacked annular labyrinth baffles transversely disposed across the chamber, said array of labyrinth baffles consisting of consecutive baffles which alternately communicate the seawater about their inner and outer peripheries,
   (e) said baffles having their transverse faces made of an ablative and water soluble material containing a water soluble drag reducing polymer, and
   (f) said annular channel at its front end communicating with ejection orifice means extending through the hull and opening into the exterior surface of the torpedo along a circumferential loci, said orifice means being for ejection of the polymer aqueous solution into the boundary layer flow about the torpedo.

2. Apparatus in accordance with claim 1, wherein:
   (g) said orifice means is a circumferential slot extending continuously about the torpedo.

3. Apparatus in accordance with claim 1, wherein:
   (h) the individual baffles of the array of labyrinth baffles comprising a sandwiched construction consisting of a center support member and sheets of said ablative and water soluble material bonded to each face thereof,

4. Apparatus in accordance with claim 1,
   (i) said ablative and water soluble material comprising a water soluble drag reducing polymer composited with a water soluble thermoplastic plasticizer and a water soluble filler.

5. Apparatus in accordance with claim 1, wherein:
   (j) said means for introducing ingested seawater comprises one or more forwardly facing scoops projecting laterally from the cylindrical hull of the torpedo

and communicating with the rear end of said annular channel.

6. Apparatus in accordance with claim 1, wherein:

(k) said annular channel having front and rear portions, said array of labyrinth baffles being disposed in the rear portion and said front portion being so constructed and arranged to provide a predetermined residence-time before the aqueous-polymer solution is ejected in order to allow further hydration of the polymer particles.

References Cited

UNITED STATES PATENTS

3,196,823	7/1965	Thurston	114—20 X
3,230,919	1/1966	Crawford	114—67
3,290,883	12/1966	Giles et al.	114—67 X

BENJAMIN A. BORCHELT, *Primary Examiner.*

G. H. GLANZMAN, *Assistant Examiner.*