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IN REPLY REFER TO:

Attorney Docket No. 79869  
Date: 16 February 2005

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CODE 000C, BLDG. 112T  
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Serial Number      10/839,449  
Filing Date        03 May 2004  
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**20050223 286**

LOW FREQUENCY SONAR COUNTERMEASURE

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT THOMAS A. FRANK, employee of the United States Government, citizens of the United States of America, and residents respectively of Middletown, County of Newport, State of Rhode Island has invented certain new and useful improvements entitled as set forth above of which the following is a specification:

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1 Attorney Docket No. 79869

2 LOW-FREQUENCY SONAR COUNTERMEASURE

3

4 STATEMENT OF GOVERNMENT INTEREST

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

9

10 BACKGROUND OF THE INVENTION

11 (1) Field of the Invention

12 The present invention relates generally to active sonar  
13 countermeasures. More particularly, this invention relates to a  
14 cost effective, cylindrically shaped acoustic countermeasure  
15 that lowers transmitted frequencies by one half as compared to  
16 contemporary transducers of the same size.

17 (2) Description of the Prior Art

18 Acoustic countermeasures are an integral part of undersea  
19 offensive and defensive operations, and compact transducers are  
20 routinely used as expendable acoustic sources. The expendable  
21 sources can project acoustic energy over bandwidths that are  
22 predetermined or limited by the dimensions of a source's  
23 cylindrical-shaped housing. The current state of the art  
24 expendable acoustic source is only capable of projecting

1 acoustic energy at a low end frequency level that is  
2 approximately two times higher than the desired or optimum low  
3 frequency for successful countermeasure operations.

4 The size of a source's housing and hence the lowest  
5 operating frequencies are constrained by the dimensions of the  
6 launch or deployment systems in the submerged or surface vessel.  
7 Larger acoustic countermeasures would be capable of lower  
8 frequency operation, but larger sound sources are incompatible  
9 with existing systems used to deploy expendable acoustic  
10 countermeasures.

11 Thus, in accordance with this inventive concept, a need has  
12 been recognized in the state of the art for an expendable  
13 cylindrical-shaped acoustic source that is capable of operating  
14 at one half the present lowest operating frequency of a  
15 contemporary source of similar dimensions.

16

#### 17 SUMMARY OF THE INVENTION

18 The first object of the invention is to provide a multi-  
19 port underwater projector of acoustic energy.

20 Another object is to provide a multi-port projector that is  
21 capable of projecting acoustic energy at about one half the  
22 lowest frequency of a contemporary source of similar size.

1 Another object is to provide a multi-port projector that is  
2 capable of projecting acoustic energy at about one half the  
3 lowest frequency of a contemporary source of similar size.

4 Another object is to provide a multi-port acoustic energy  
5 projector compatible with existing allotted spaces in a  
6 countermeasure device and capable of projecting acoustic energy  
7 at one half the lowest frequency of a similar sized contemporary  
8 source.

9 Another object is to provide a multi-port projector of  
10 acoustic energy having thin flexible members, such as membranes  
11 or thin plates at opposite ends of a cylindrical transducer.

12 Another object is to provide an acoustic projector having  
13 flexible members at opposite ends of a cylindrical transducer to  
14 fit into an existing allotted space in a countermeasure device  
15 and project acoustic energy.

16 Another object is to provide a cylinder-shaped acoustic  
17 source having flexible membranes extending across a cylindrical  
18 transducer containing a power source/electronics in liquid-  
19 filled voids and spaces.

20 These and other objects of the invention will become more  
21 readily apparent from the ensuing specification when taken in  
22 conjunction with the appended claims.

23 Accordingly, the present invention is a multi-port  
24 projector of acoustic energy in water that includes a

1 cylindrical hollow transducer having annular ends around an  
2 opening. A thin, flexible member is secured to each annular end  
3 to extend across each opening to be displaced by the transducer.  
4 The transducer and flexible members form an interior that is  
5 sealed from ambient water. The thin flexible members can be  
6 either thin, disc-shaped flexible membranes or thin disc-shaped  
7 plates. A battery/electronics module is in the interior and is  
8 spaced from the transducer and flexible members to couple  
9 driving signals to the transducer for reciprocally displacing it  
10 and the flexible members in response to the driving signals.

11 An inert liquid fills the interior around the module, and  
12 an open truss on each annular end exposes the flexible members  
13 to the ambient water. Cylindrical portions coaxially extending  
14 with the transducer on a common longitudinal axis are connected  
15 to the open trusses for projecting acoustic energy of a lower  
16 frequency than conventional cylindrical transducers of similar  
17 size.

18 The battery/electronics module includes a battery section  
19 and an electronics section to couple the driving signals to the  
20 transducer. The electronics section has a case containing  
21 electronic components, and the inert liquid fills voids around  
22 the components in the case. A duct extends from the battery  
23 section to the ambient water to flood the battery section  
24 thereby activating seawater batteries in the battery section.

1 BRIEF DESCRIPTION OF THE DRAWINGS

2 A more complete understanding of the invention and many of  
3 the attendant advantages thereto will be readily appreciated as  
4 it becomes better understood by reference to the following  
5 detailed description when considered in conjunction with the  
6 accompanying drawings wherein like reference numerals refer to  
7 like parts and wherein:

8 FIG. 1 is a schematic showing of a low frequency sonar  
9 multi-port projector of the invention in an allotted space in a  
10 countermeasure device; and

11 FIG. 2 is a schematic cross-sectional showing of the low  
12 frequency sonar multi-port projector of the invention.

13  
14 DESCRIPTION OF THE PREFERRED EMBODIMENTS

15 Referring to the FIG. 1 and 2 there is illustrated a multi-  
16 port projector 10 of acoustic energy of the invention is  
17 included as a part of an elongate cylinder-shaped countermeasure  
18 device 4. Countermeasure device 4 has a diameter of only a few  
19 inches allowing it to be fitted into an individual launch tube  
20 of a compact launcher system (not shown) for deployment into  
21 seawater 9.

22 Multi-port projector 10 has a diameter of only a few inches  
23 and is substantially the same diameter as cylindrical-shaped  
24 portions 7 of countermeasures device 4 so that it can be

1 securely fitted between cylindrical-shaped portions 7.  
2 Cylindrical-shaped portions 7 coaxially extend in opposite  
3 directions from multi-port projector 10 in allotted space 5  
4 along a common longitudinal axis 6. Cylindrical-shaped portions  
5 7 can have sensors/instrumentation, guidance/propulsion,  
6 electronics, and/or ordnance, etc. in rigid shells 8 on each  
7 portion 7 to perform other tactical functions of countermeasures  
8 device 4.

9 Multi-port projector 10 is a cylindrical projector of  
10 acoustic energy having an elongate cylindrical hollow  
11 magnetostrictive, or piezoelectric transducer 11. Transducer 11  
12 can have a thin, strong metal or plastic shell 13 (for  
13 protection from abuses and watertight integrity) that is  
14 slightly separated from transducer 11 by a thin layer 14 of  
15 electrical insulation. Protective shell 13 could also be a  
16 watertight layer or coating of rugged, flexible insulation  
17 material bonded onto transducer 11 or insulation layer 14 that  
18 will withstand the rigors of handling and deployment yet will  
19 flex as transducer 11 is displaced. Shell 13 seals out or is  
20 impervious to ambient water 9 over expected depths of operation.  
21 Transducer 11 with shell 13 can be considered the hull portion  
22 of multi-port projector 10 of countermeasures device 4.  
23 Transducer 11 (and shell 13) can be connected at its opposite  
24 annular ends 12 (and end 13A of shell 13) to an open truss 15 of



1 rigid members 15A that extend through portions 9A of ambient  
2 seawater 9. Each truss 15 is also secured at its opposite end  
3 to one end 8A of rigid shells 8 of cylindrical portions 7.  
4 Trusses 15 can sandwich circumferential annular strips of  
5 flexible members 16 between them and annular ends 12 & ends 13A  
6 of shell 13.

7 Cylindrical hollow magnetostrictive transducer 11 can be  
8 any of many well know designs that can have stacked ring-shaped  
9 magnetostrictive portions interleaved with serial or parallel  
10 connected electrodes. The exact construction and  
11 interconnection need not be further elaborated on or shown to  
12 avoid unnecessary detail concerning what is of general knowledge  
13 in the art. For purposes of demonstration of this inventive  
14 concept, however, a single electrode 12A at opposite ends of  
15 transducer 11 is shown to be suitably attached and  
16 interconnected to create and impart responsive longitudinal  
17 reciprocal displacements thereof along the longitudinal axis 6  
18 of countermeasures device 4 in accordance with or in response to  
19 applied driving signals (shown as arrows 24A). Optionally,  
20 transducer 11 could be polarized to impart responsive reciprocal  
21 radial displacements if desired.

22 A very thin and flexible disc-shaped member 16 such as a  
23 thin membrane or thin disc-shaped plate is disposed on each  
24 annular opposite end 12 of transducer 11 to radially inwardly

1 extend across it. Flexible members 16 are connected or secured  
2 to annular ends 12 of transducer 11 in a sealed relationship and  
3 can be connected directly to annular opposite ends 12 and  
4 protective shell 13 by a wide variety of well known means, such  
5 as for example, by a commercially available heavy duty epoxy-  
6 like bonding agent. Flexible members 16 are thin with respect  
7 to the wavelengths of interest, which in this case are the  
8 projected low-frequency signals. Since thin flexible members 16  
9 will flex so freely, to the cylindrical multi-port projector 10  
10 it appears as if there are no end plates. Consequently, this  
11 construct creates multiple ports for multi-port projector 10,  
12 and the cylinder-shaped structure of transducer 11 of multi-port  
13 projector 10 with cylindrical-shaped portions 7 becomes, or is  
14 the hull of, countermeasure device 4. Transducer 11 (and shell  
15 13) can be connected at its opposite annular ends 12 (and end  
16 13A of shell 13) to an open truss 15 of rigid members 15A that  
17 extend through portions 9A of ambient seawater 9. Each truss 15  
18 is also secured at its opposite end to one end 8A of rigid  
19 shells 8 of cylindrical portions 7. Trusses 15 can sandwich  
20 circumferential annular strips of flexible members 16 between  
21 them and annular ends 12 & ends 13A of shell 13.

22 A battery/electronics module 20 can be held in a position  
23 spaced away inwardly from transducer 11 and thin end plates 12  
24 by resilient members 21 inside of hollow transducer 11. Being so

1 resilient, or compliant, resilient members 21 do not overly  
2 restrict or compromise the reciprocal excursions of transducer  
3 11 as low- frequency acoustic signals are created and  
4 transmitted from multi-port projector 10 of countermeasures  
5 device 4. A battery section 22 of battery/electronics module 20  
6 provides sufficient electrical power for an interconnected  
7 electronics section 24 of battery/electronics module 20 to  
8 enable electronics section 24 to generate predetermined driving  
9 signals 24A for transducer 11.

10 Multi-port projector 10 has an interior 17 that is enclosed  
11 by transducer 11 and thin end plates 16 and contains  
12 battery/electronics module 20. The part of interior 17 that is  
13 not filled by battery/electronics module 20 is filled completely  
14 with an inert liquid 18 such as a high-purity isoparaffinic  
15 solvent with a narrow boiling range. In the preferred  
16 embodiment, inert liquid 18 would be the trademarked solvent  
17 ISOPAR produced by Exxon Mobil Corporation 3625 Gallow Road,  
18 Fairfax, VA 22037. Because the volume of interior 17 that is  
19 outside of battery/electronics module 20 is filled completely  
20 with inert liquid 18, a lower-frequency projection of acoustic  
21 energy is created.

22 The inside of a case 25 containing electronic components 26  
23 of electronics section 24 of battery/electronics module 20 may  
24 have small air-filled spaces or voids 27 around components 26.

1 Inert liquid 18 is used to fill spaces 27 to further improve  
2 performance of multi-port projector 10. Since battery section  
3 22 is most likely to be a seawater battery, some of the ambient  
4 seawater (shown as arrows 9B) can flow into the seawater battery  
5 of battery section 22 through a pair of sealed resilient ducts  
6 23 extending through transducer 11 or other convenient  
7 transition points while multi-port projector 10 sinks in water  
8 9. Ducts 23 allow flooding and filling of battery section 22  
9 with some of ambient seawater 9 for ensuing activation of  
10 battery section 22. Battery section 22 could also be a sealed  
11 structure and does not need to be flooded or activated with a  
12 part of ambient seawater 9; however, such a structure may be  
13 more susceptible to the problems associated with overheating  
14 than a seawater battery.

15 Electronics section 24 has leads 25 coupled to connect  
16 driving signals 24A to annular electrodes 12A at opposite  
17 annular ends of transducer 11 and create responsive  
18 reciprocating displacements of transducer 11 and impart  
19 responsive reciprocating displacements of thin flexible members  
20 16. The reciprocating displacements of transducer 11 transmit  
21 representative acoustic signals at opposite ends of multi-port  
22 projector 10 via thin, flexible members 16 that radiate to open  
23 water 9 through portions 9A of water 9 in both open trusses 15.  
24 The reciprocating displacements of transducer 11 also transmit

1 the same representative acoustic signals at opposite ends of  
2 multi-port projector 10 through the rigid members 15A of both  
3 trusses 15 to both rigid shells 8 of cylindrical portions 7 that  
4 radiate into open water 9. In other words, the entire hull of  
5 the countermeasure device 4 that includes multi-port projector  
6 10 connected by trusses 15 to cylindrical portions 7 will become  
7 a large multi-port transducer that will operate at much lower  
8 frequency than a conventional cylindrical transducer of the same  
9 size.

10 Multi-port projector 10 of the invention projects acoustic  
11 energy at about one half the lowest frequency of a comparably  
12 dimensioned contemporary transducer partially because it is  
13 liquid-backed. That is, multi-port projector 10 is filled with  
14 inert liquid 18 in interior 17 around battery/electronics module  
15 20, is filled with inert liquid 18 around components 26 in case  
16 25 of electronics section 24, and substantially filled with  
17 seawater in its battery section 22. This also provides the  
18 added operational advantage of heat dissipation. Furthermore,  
19 1.) making transducer 11 and battery section 22 essentially the  
20 same length as multi-port projector 10, 2.) having liquid 18  
21 filling the surrounding battery/electronics module 20 directly  
22 against the inside of transducer 11, and 3.) having transducer  
23 11 covered or capped by thin flexible members 16 exposed to  
24 seawater 9 via open trusses 15 at opposite ends, assures

1 excitation of countermeasure device 4 and projection of acoustic  
2 energy at the lower frequencies desired.

3 It is understood that multi-port projector 10 could be made  
4 in accordance with this invention in different sizes in  
5 different acoustic systems for many different purposes where  
6 lower frequency operation is needed. Other transducers such D.C.  
7 linear motors could be used instead of magnetostrictive elements  
8 and different arrangements of batteries and electronics could be  
9 used without departing from the scope of this invention herein  
10 described. Having this disclosure in mind, selection of  
11 suitable components from among many proven contemporary designs  
12 and compactly interfacing them as disclosed herein can be  
13 readily done without requiring anything beyond ordinary skill.

14 The components and their arrangements as disclosed herein  
15 all contribute to the novel features of this invention. Multi-  
16 port projector 10 of this invention provides a reliable and  
17 cost-effective means to improve the low-frequency response of  
18 countermeasures. Therefore, multi-port projector 10 as  
19 disclosed herein is not to be construed as limiting, but rather,  
20 is intended to be demonstrative of this inventive concept.

21 It will be understood that many additional changes in the  
22 details, materials, steps and arrangement of parts, which have  
23 been herein described and illustrated in order to explain the  
24 nature of the invention, may be made by those skilled in the art

- 1 within the principle and scope of the invention as expressed in
- 2 the appended claims.

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LOW FREQUENCY SONAR COUNTERMEASURE

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ABSTRACT OF THE DISCLOSURE

6 A multi-port projector of acoustic energy in water includes  
7 a cylindrical hollow transducer having open annular ends. A  
8 thin, flexible member is secured to each annular end to extend  
9 across each opening to be displaced by the transducer, and the  
10 transducer and flexible members form an interior sealed from  
11 ambient water. A battery/electronics module is in the interior  
12 and is spaced from the transducer and flexible members to couple  
13 driving signals to the transducer for reciprocally displacing it  
14 and the flexible members in response to the driving signals. An  
15 inert liquid fills the interior around the module, and an open  
16 truss on each annular end exposes the flexible members to the  
17 ambient water. Cylindrical portions coaxially extending with  
18 the transducer on a common longitudinal axis are connected to  
19 the open trusses for projecting acoustic energy of lower  
20 frequency than conventional cylindrical transducers of similar  
21 size.



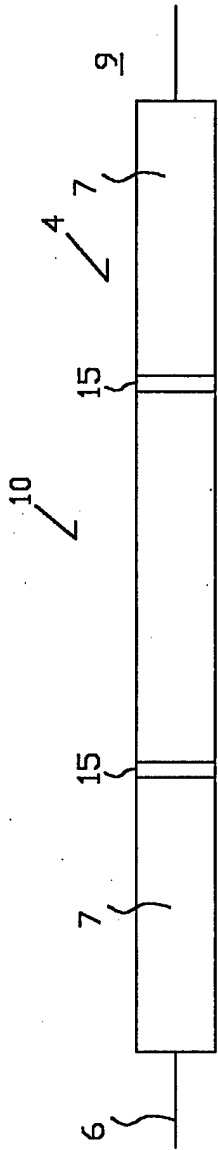


FIG. 1

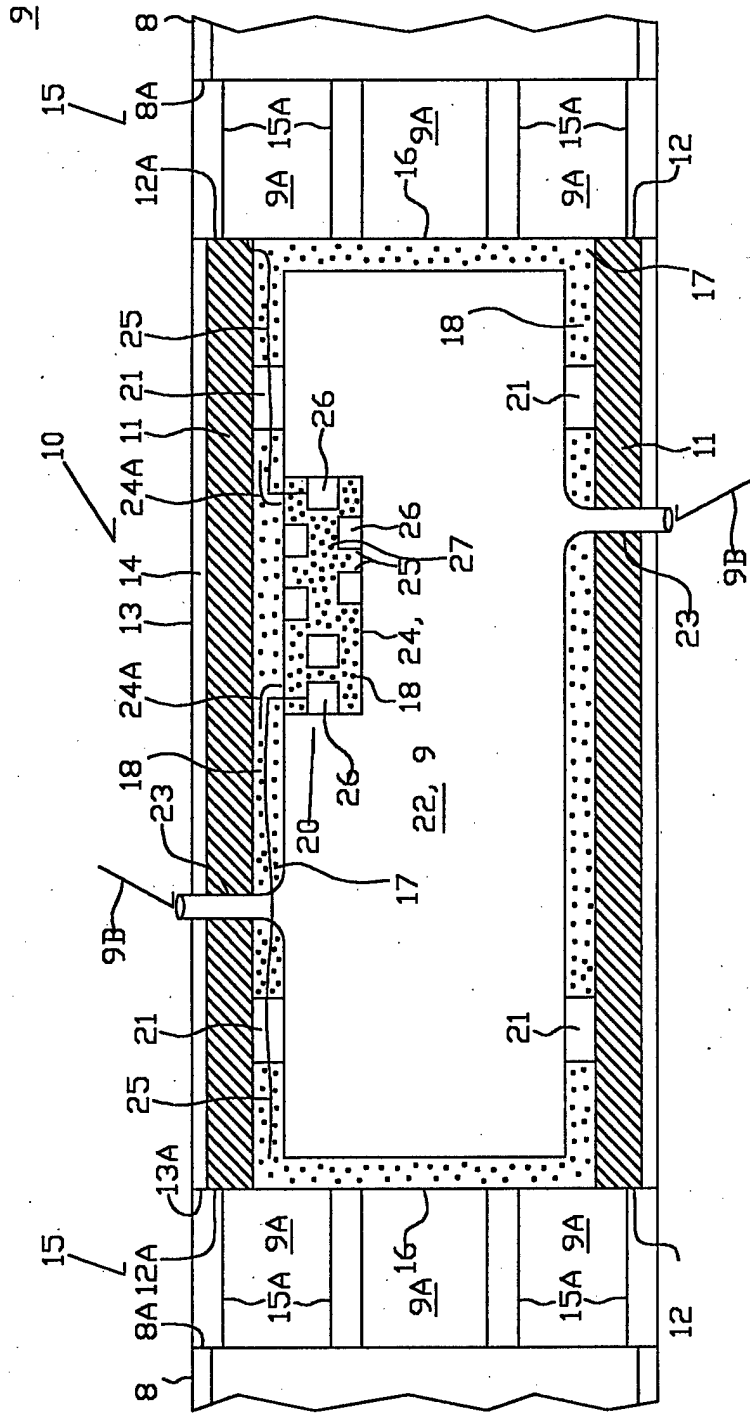


FIG. 2