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3 FLOW RELEASE ELASTOMERIC EJECTION SYSTEM

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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 The invention relates to an elastomeric vehicle launching
14 system, and more particularly to a low noise, low volume, low
15 elastomeric strain impulse fluid delivery apparatus of concentric
16 elastomeric rings.

17 (2) Description of the Prior Art

18 Impulse fluid flows are used to launch vehicles from
19 submarine platforms. Launch systems in the prior art include the
20 single stroke reciprocating pump, and the rotary air turbine
21 pump. Additionally, elastomeric ejection systems have been

1 developed, which store impulse fluid in charged elastomeric
2 bladders.

3 The single stroke reciprocating pump converts pneumatic
4 potential energy from compressed air stored in a flask into
5 working fluid kinetic energy. The pump utilizes a massive piston
6 apparatus to transfer sufficient working fluid, such as seawater,
7 to launch a projectile. The system has proven reliable, but has
8 significant disadvantages. Its complexity results in high system
9 and maintenance cost, and the rapid conversion of pneumatic
10 potential energy into the vehicle kinetic energy results in
11 significant radiated noise.

12 The air rotary turbine pump also converts potential energy
13 in the form of compressed air stored in a flask into kinetic
14 energy of a working fluid. An air turbine drive unit is joined
15 with a rotary impeller pump via a speed reduction unit. This
16 system suffers from disadvantages similar to those of the single
17 stroke reciprocating pump.

18 An alternative type of launch system is the elastomeric
19 ejection system (EES) which addresses the problems of the single
20 stroke reciprocating pump and the air rotary turbine pump. U.S.
21 Patent No. 4,848,210 discloses an elastomeric impulse energy
22 storage and transfer system. The system of this patent is

1 adapted to a torpedo launch system wherein an elastomeric bladder
2 is distended by filling it with pressurized fluid. When a fluid
3 impulse is desired, the elastomeric bladder discharges its volume
4 of working fluid to eject a projectile from the launch system
5 into the surrounding liquid. The elastomeric bladder used is
6 generally spherical, containing an expanded volume sufficient to
7 fill the launch tube and the launch way forward of the launch
8 tube.

9 U.S. Patent No. 5,200,572 discloses an EES bladder, which
10 has an elevation of frusto-ellipsoidal configuration and an
11 ellipsoidal sectional plane parallel to the base of the bladder.

12 The bladder of this patent is aimed at achieving a smooth and
13 even flow of impulse fluid from the bladder to further reduce
14 radiated noise.

15 U.S. Patent No. 5,231,241 further discloses an EES
16 configuration in which a submarine hull partially defines the
17 volume of fluid stored in the elastomeric bladder. An impulse
18 tank is defined by the volume between the inner hull and an
19 elastomeric sheet. Pressurized liquid causes the diaphragm to
20 expand within the outer hull to generate the required potential
21 energy for a launch. U.S. Patent No. 5,231,241 is hereby
22 incorporated by reference.

1 The above EES systems suffer from cavitation noise following
2 launch. When the finite volume of fluid in the bladder is
3 exhausted a low pressure region forms, causing cavitation on the
4 inside surface of the elastomeric bladder. U.S. Patent No.
5 5,410,978 discloses a flow-through EES aimed at preventing
6 cavitation noise. A cylindrical elastomeric bladder is disposed
7 within a bypass tube, open at one end. When the bladder is
8 filled with fluid, the walls of the bladder contact the walls of
9 the bypass tube at a sealing ring, sealing the system from the
10 outside fluid atmosphere. When the fluid in the bladder is
11 discharged, the bladder unseats from the bypass tube, allowing
12 free flow of fluid from the outside fluid atmosphere toward the
13 impulse fluid.

14 Another patent further illustrative of the art is U.S.
15 Patent No. 5,645,006 which discloses a bladder assembly for
16 retaining fluid under pressure.

17 A primary disadvantage of prior art EES systems is the high
18 level of elastic strain on the charged bladder resulting in
19 unstable bladder geometry and reduced material cyclic life. A
20 further disadvantage is the undesirable cavitation noise which
21 can occur following launch. Another disadvantage is that large
22 bladder volumes are required to ensure successful vehicle launch

1 before a bladder is exhausted. Further, the prior art flow
2 through EES also suffer from undesirable system complexity.

3

4 SUMMARY OF THE INVENTION

5 Accordingly, it is a general purpose and primary object of
6 the present invention to provide an improved elastomeric ejection
7 system (EES) for delivering impulse fluid to a vehicle.

8 A primary object of the invention is to provide a low volume
9 launch system, which produces a minimal amount of radiated noise.

10 A further object of the invention is to provide a system
11 with a long material cyclic life.

12 A still further object of the invention is to provide a
13 mechanically simple, low cost EES.

14 In furtherance of the purpose and objects of the invention,
15 a flow release elastomeric ejection apparatus and assembly are
16 provided, featuring a ring-type diaphragm of concentric
17 elastomeric rings, able to accept pressurized fluid and storing
18 elastic potential energy in shear strain.

19 The ring diaphragm of the assembly comprises a series of
20 concentric elastomeric rings, coupled to one another and
21 alternating with rigid rings. These rings radiate inward toward
22 a central disc to form an impermeable diaphragm. The ring

1 diaphragm is adapted to be incorporated within a launch system
2 such that pressurized fluid can be presented to an inner side of
3 the diaphragm. Thus, the diaphragm is placed across an opening
4 between two separate volumes of fluid. For example, the ring
5 diaphragm can be attached such that it partially defines an
6 impulse tank. When fluid pressure is increased on the inner side
7 of the ring diaphragm, the elastomeric rings deform in shear
8 strain to accept the additional fluid. Potential energy for
9 launch is stored in the strained rings. Fluid release provides
10 the impulse energy required for a launch and allows the ring
11 diaphragm to return to its resting position.

12 A preferred flow release aspect of the invention comprises a
13 one-way central check valve, which is a modified central disc.
14 The check valve includes cut-outs in the central disc and valve
15 flaps having seated and open positions in relation to the cut-
16 outs. Following launch, excess fluid pressure on an outer side
17 of the ring diaphragm causes the valve flaps to unseat and swing
18 open, allowing fluid to flow through the ring diaphragm behind
19 the impulse fluid. The resulting fluid pressure equilibration
20 across the ring diaphragm prevents cavitation noise and makes a
21 smaller impulse fluid volume feasible.

1 A further aspect of the present invention is an integrated
2 vehicle launch assembly including the ring diaphragm of the
3 invention. The ring diaphragm partially defines an impulse tank
4 within the outer hull of a submarine. A pump transfers fluid
5 from a free flood area to charge the impulse tank and the ring
6 diaphragm. Launch is achieved by opening a slide valve
7 connecting the impulse tank to a launch tube containing the
8 launch vehicle. As the ring diaphragm deflates, the impulse
9 fluid flows from the impulse tank into the launch tube forcing
10 the vehicle out of the launch tube. Following launch, the check
11 valve is forced open by fluid pressure in the free flood area,
12 allowing fluid to flow from through the ring diaphragm into the
13 impulse tank and toward the launch tube.

14 The ring diaphragm of the present invention will provide a
15 long material cyclic life because the elastomeric rings are
16 placed in shear strain (as opposed to extension), thereby
17 subjecting the material to milder levels of strain than required
18 of prior art elastomeric bladders. Further, the check valve
19 feature of the invention prevents noisy cavitation by allowing
20 free flow of fluid through the ring diaphragm from outside after
21 launch. The check valve also makes possible a low overall system
22 volume, because rapid deceleration of the impulse fluid is

1 avoided. The central check valve is an optional but preferred
2 feature of the invention, and additionally, the number of
3 concentric rings in the accumulator may be modified.

4

5 BRIEF DESCRIPTION OF THE DRAWINGS

6 A more complete understanding of the invention and many of
7 the attendant advantages thereto will be readily appreciated as
8 the same becomes better understood by reference to the following
9 detailed description when considered in conjunction with the
10 accompanying drawings wherein:

11 FIG. 1 is a sectional diagrammatic view of the bow of a
12 submarine showing a vehicle launch assembly including the ring
13 diaphragm of the present invention in its resting position;

14 FIG. 2 is an enlarged top plan view of the ring diaphragm of
15 the invention showing, among other features, the concentric rings
16 and the central check valve shown in partial cutaway;

17 FIG. 3 is an enlarged cross-sectional view along lines 3-3
18 of the ring diaphragm shown in FIG. 2, depicting the ring
19 diaphragm in its fully charged position; and

20 FIG. 4 is a view of the ring diaphragm shown in FIG. 3
21 depicting the ring diaphragm in its flow release position.

1 DESCRIPTION OF THE PREFERRED EMBODIMENT

2 Referring now to FIG. 1, there is shown a diagrammatic view
3 of the bow of a submarine, cut away to display an illustrative
4 launch assembly in accordance with the present invention.

5 The outer hull 10 and the inner hull 12 of the bow define a
6 free flood area 14 which is open to outside seawater through one
7 or more openings 16 in the outer hull 10. A pump 18 is provided
8 within the inner hull and has a suction side, adapted to draw
9 fluid from the free flood area 14, and a discharge side to inject
10 pressurized fluid into an impulse tank 20.

11 Impulse tank 20 is defined by the submarine inner hull 12,
12 impulse tank walls 22 extending from inner hull 12, and a ring
13 diaphragm 24. Ring diaphragm 24 is shown in FIG. 1 in its
14 resting position.

15 Referring to FIG. 2, a top plan view of ring diaphragm 24 is
16 shown. Outer base ring 30 supports the ring diaphragm and
17 secures it to the walls 22 of impulse tank 20. Radiating inward
18 from the base ring 30 is a series of two elastomeric rings 32 and
19 34, alternating with two rigid steel rings 36 and 38. At the
20 center of ring diaphragm 24 is central check valve 40 (shown in
21 partial cutaway) with four flow release cutouts 42 and valve

1 flaps 44. The elastomeric rings 32 and 34 can be of neoprene,
2 natural rubber, or the like.

3 Returning to FIG. 1, a launch tube 50 has a breach end 54
4 and a mouth 52 containing muzzle valve 53. The launch tube 50
5 communicates with impulse tank 20 when a flow controlling slide
6 valve 56 is moved to its open position. With the slide valve 56
7 closed, the impulse tank 20 can be charged. The submarine
8 utilizes fluid in free flood area 14, provided through an opening
9 16 in outer hull 10. The fluid is drawn in by pump 18, as
10 indicated by the arrow 15, so as to charge the impulse tank 20
11 and to cause the elastomeric rings 32 and 34 of ring diaphragm 24
12 to deform in shear strain.

13 Referring to FIG. 3, a sectional view of ring diaphragm 24
14 taken along 3-3 of FIG. 2 illustrate the ring diaphragm in its
15 fully charged position. Increased pressure in the impulse tank
16 20 causes elastomeric rings 32 and 34 to deform in shear strain
17 to accept the pressurized fluid being added. When pressure in
18 impulse tank 20 exceeds pressure in free flood area 14, check
19 valve 40 is closed. Valve flaps 44 are seated against flow
20 release cutouts 42, preventing escape of fluid from the impulse
21 tank 20. The amount of displacement permitted by the elastomeric
22 rings 32, 34 is controlled by the charged volume of the impulse

1 tank 20. The required potential fluid energy can be stored at
2 below 50% shear strain.

3 Returning to FIG. 1, a fluid impulse can be delivered from
4 the charged impulse tank 20 to launch tube 50 by opening slide
5 valve 56. This fluid impulse ejects launch vehicle 58 from the
6 submarine.

7 As the impulse fluid is discharged, elastomeric rings 32 and
8 34 begin to return to the resting state. Referring to FIG. 4, a
9 sectional view of ring diaphragm 24 in its flow release position
10 is shown. Displacement stops 37 and 39, which extend from
11 impulse tank walls 22, are positioned in the path of rings 36 and
12 38. The displacement stops 37, 39 halt the motion of the
13 deflating ring diaphragm 24, preventing a reversal and
14 maintaining a slight positive shear strain in the elastomeric
15 rings 32 and 34 so that crystalline structures within the
16 elastomer will resist crack propagation. Displacement stops 37
17 and 39 are constructed in a step-down configuration such that
18 displacement stop 39 permits a slightly larger range of motion
19 than does displacement stop 37.

20 As further shown in FIG. 4, when rigid rings 36 and 38
21 contact displacement stops 37 and 39, dashpot cavities 46 and 48
22 are created. The rigid rings 36 and 38 trap an amount of fluid

1 within the cavities, causing a smooth and quiet arrest to rings
2 36 and 38 against stops 37 and 39.

3 Returning again to FIG. 1, it is noted that the discharge of
4 pressurized fluid from impulse tank 20 can create a pressure
5 differential such that fluid pressure in the free flood area 14
6 is higher than that in launch tube 50 and impulse tank 20.
7 Without equilibration, noisy cavitation can occur on the surface
8 of the ring diaphragm 24.

9 As shown in FIG. 4, central check valve 40 is in its flow
10 release position. Higher fluid pressure in free flood area 14
11 holds valve flaps 44 open, allowing fluid to enter the impulse
12 tank 20 through cut-outs 42, and flow toward the launch tube 50.
13 Thus, cavitation is prevented. The flow release feature also
14 permits a smaller impulse fluid volume, because rapid
15 deceleration of flow is avoided. This in turn results in shorter
16 recharge times. The central location of the check valve has the
17 advantage of providing a smoother flow through the system than a
18 peripheral valve would permit. Additionally, the integrated
19 valve/ring configuration of ring diaphragm 24 provides a
20 mechanically simple ejection system. Once equilibration has
21 occurred, impulse tank 20 is ready for recharging.

1 In light of the above, it is therefore understood that
2 the invention may be
3 practiced otherwise than as specifically described.

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3 FLOW RELEASE ELASTOMERIC EJECTION SYSTEM

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5 ABSTRACT OF THE DISCLOSURE

6 An apparatus for providing a rapid fluid impulse which can
7 be used for launching vehicles into a liquid medium. The
8 apparatus comprises a ring diaphragm of coupled concentric
9 elastomeric rings, adapted to accept pressurized fluid at an
10 interior side. The pressurized fluid extends the elastomeric
11 rings of the ring diaphragm, placing them in shear strain. When
12 the fluid is released, a kinetic impulse is provided and the ring
13 diaphragm returns to its resting position. The apparatus further
14 comprises a central check valve on the ring diaphragm. The check
15 valve allows fluid to flow from an exterior side, through the
16 ring diaphragm, to the interior side when exterior fluid pressure
17 exceeds interior pressure. The invention is useful in a
18 submarine vehicle launch assembly wherein the ring diaphragm is a
19 component thereof.

