United States Patent [19]

McLean et al.

[11] **3,764,965**

[45] **Oct. 9, 1973**

[54] **PROJECTOR OF ACOUSTIC ENERGY**

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[73] Assignee: **The United States of America as represented by the Secretary of the Navy,** Washington, D.C.

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[21] Appl. No.: **263,499**

[52] **U.S. Cl.** .... **340/12,** 181/.5 H, 340/8 R

[51] **Int. Cl.** **H04b 13/00**

[58] **Field of Search** .... 340/8, 12, 14, 4, 340/5, 15; 181/.5 A, .5 H, .5 XC, .5 R

[56] **References Cited**

UNITED STATES PATENTS

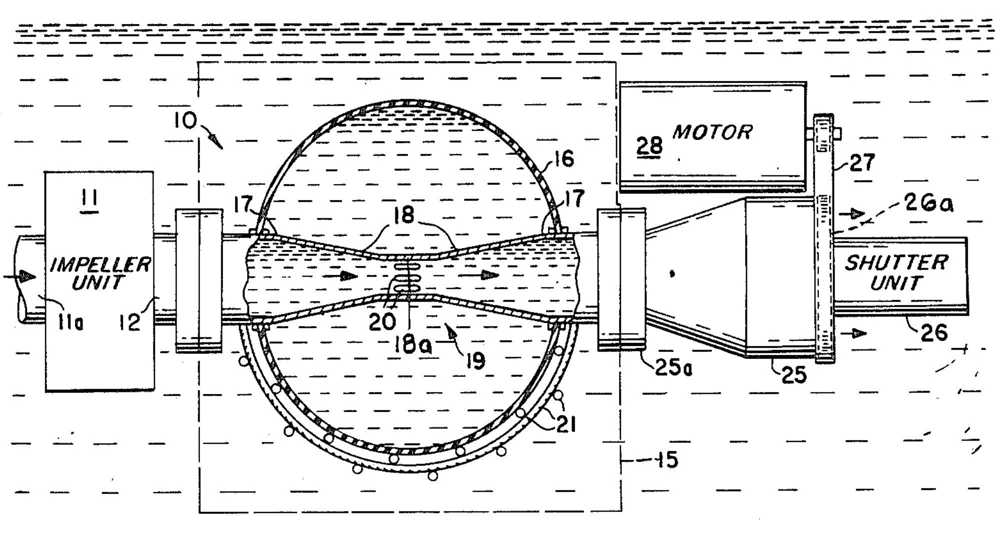
3,376,949	4/1968	Baker et al.	181/.5
3,432,804	3/1969	Beeken	340/15
3,392,369	7/1968	Dickie et al.	340/12 R
3,713,417	1/1973	Shugart	340/15
3,277,437	10/1966	Bouyoucos	340/12 R
3,403,374	9/1968	Mellen et al.	340/12 R X
3,536,157	10/1970	Anstey	340/12 R X
3,458,858	7/1969	Wright, Jr.	340/12 R
3,275,977	9/1966	Bouyoucos	340/15

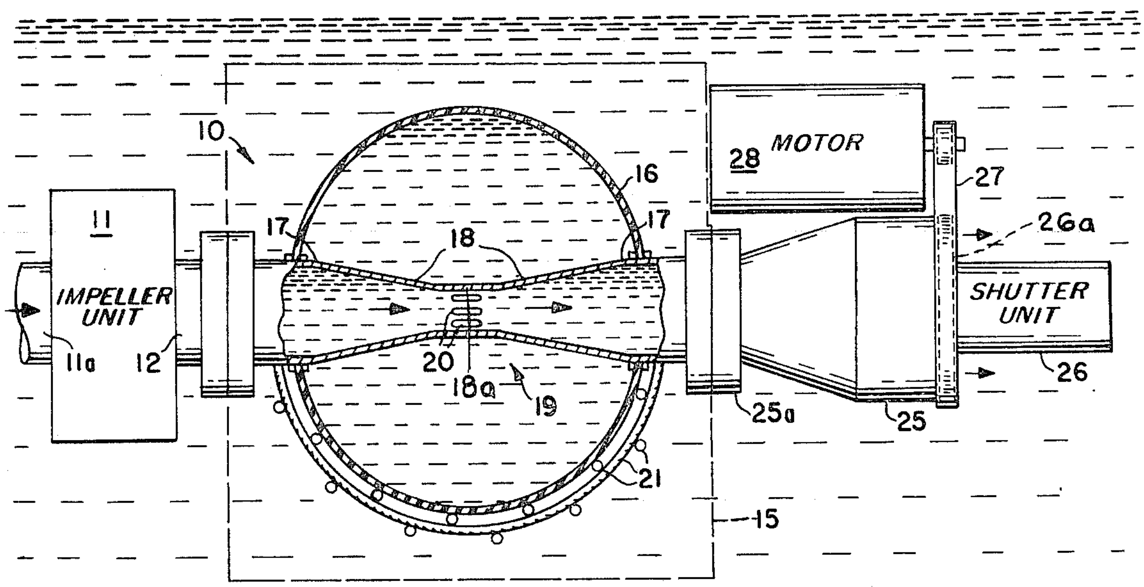
Primary Examiner—Benjamin A. Borchelt
Assistant Examiner—H.J. Tudor
Attorney—Richard S. Sciascia et al.

[57] **ABSTRACT**

A hydroacoustic transducer having a motor-pump unit drawing in ambient water impells the water to a chamber and through a rotary shutter unit which modulates the flow in an on-off sequence. The on-off modulated flow passes through an interposed venturi section creating a corresponding sequence of positive and negative hydraulic pressure impulses. These impulses are fed to the radiating surfaces of an acoustic-energy projector to reciprocally displace them accordingly. Having the transducer substantially filled with water renders it relatively insensitive to ambient pressure variations to ensure reliable operation irrespective of depth.

6 Claims, 2 Drawing Figures

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IMPELLER UNIT
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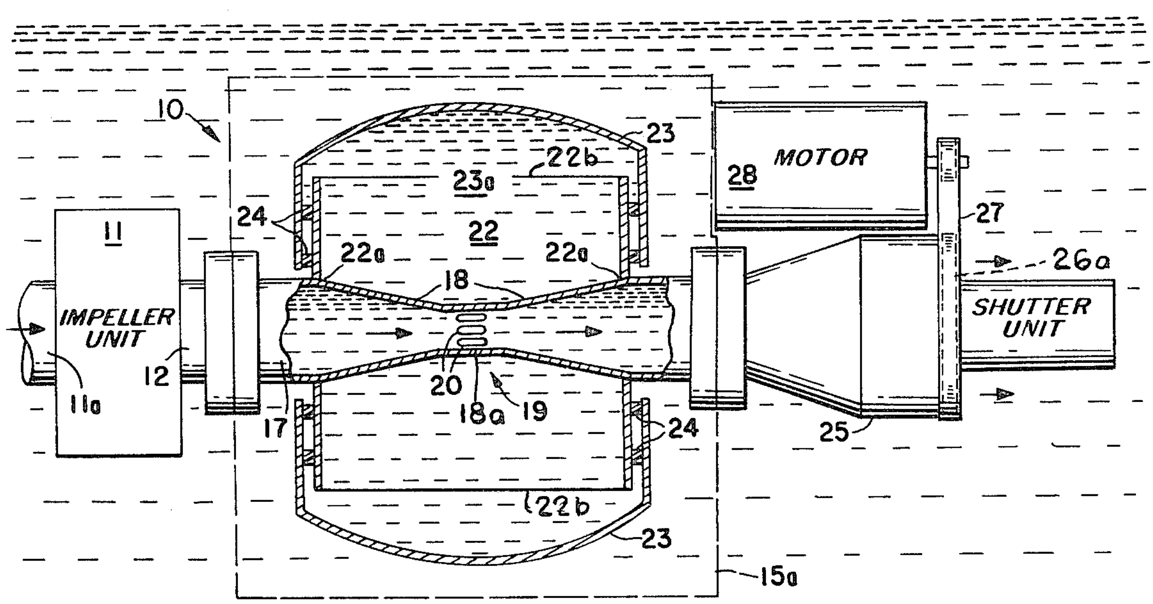
FIG. 1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SHUTTER UNIT
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FIG. 2

PROJECTOR OF ACOUSTIC ENERGY

STATEMENT OF GOVERNMENT INTEREST

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.

CROSS REFERENCE TO RELATED APPLICATIONS

There is disclosed and claimed herein an unobvious improvement over the "Hydrodynamic Transducer" disclosed and claimed in the U.S. Pat. No. 3,704,443 issued Nov. 28, 1972 to Edgar N. Rosenberg.

BACKGROUND OF THE INVENTION

Most contemporary ferroelectric and magnetostrictive transducers require elaborate sealing assemblies and pressure-compensation packings or are oil filled to prevent failure especially where the transducer is to be operated at great depths. A series of noteworthy attempts to overcome the effects of varying ambient pressures are shown in a series of hydraulically actuated transducers designed by a J. V. Buoyocous and disclosed in U.S. Pat. Nos. 2,792,804, 3,143,999 and 3,275,977. These closed-system devices convert hydraulic flow into acoustic energy in response to an internally actuated valve mechanism. Even a casual inspection reveals that the Buoyocous devices are complex and, if their hydraulic systems fail or leaks occur, small particles of impurities which gain access into these systems could seriously impair their ability to function. An alternate approach employs a freely-flooded source of acoustic energy, such as that disclosed in U.S. Pat. No. 3,376,949 to B.M. Baker et al for their "Water Hammer Marine Seismic Source." This device created a series of zero-pressure-overpressure impulses to ensonify the marine topography. However, a defect became apparent after prolonged operation, in that the overpressure impulses would tend to fatigue the hammer's resilient radiating surface. Another mentionable advance in the evolving development of hydroacoustic transducers is disclosed in the U. S. Pat. No. 3,536,157 to N. A. Anstey entitled "Underwater Sound Sources." This sound source is pulled through the water and interrupts an entrained mass of flowing water to create a series of no-pressure-overpressure impulses to project acoustic energy. While Anstey's approach eliminates a water impeller and avoids most sealing problems, from a strength-of-materials standpoint the repeated over-pressure-underpressure sequences may limit the useful life of this source. Furthermore, the absence of a large radiating surface raises a question as to whether or not any usable level of acoustic energy is capable of being generated and radiated. The above-identified U.S. Pat. No. 3,704,443 comes closest to providing an optimum design uneffected by changing pressures while being highly reliable due to its uncomplicated design. However, even in this design, the modulating series of off-on pressure impulses required strong helical springs to return the radiating surfaces to a normal position. There is evidence to suggest that including these helical springs interferes with the projection of the radiated signal. In all the contemporary acoustic sources, there is no provision made for driving radiating surfaces with a series of positive and negative hydraulic pressure impulses which by themselves hold the radiating surfaces between two extremes positions.

SUMMARY OF THE INVENTION

The present invention is directed to providing a transducer of acoustic energy including an impeller unit for feeding impelled fluid to an interrupter unit which sequentially interrupts the flow of the fluid. A venturi section interconnecting the impeller unit and the interrupter unit hydrodynamically produces positive and negative hydraulic pressure impulses in response to the sequentially interrupted flow and a radiating surface communicating with the venturi section is bidirectionally displaced in response to the positive and negative hydraulic pressure impulses.

A prime object of the invention is to provide an improved hydroacoustic transducer.

Another object of the invention is to provide a hydroacoustic transducer feeding positive and negative hydraulic pressure impulses to radiating surfaces.

Still another object of the invention is to provide a hydroacoustic transducer freely-flooded by ambient water to thereby require no pressure compensation.

Yet another object of the invention is to provide a hydroacoustic transducer driven by a series of positive and negative hydraulic pressure impulses which function to retain the radiating surfaces between two extreme positions.

A further object is to provide a hydroacoustic transducer having an elastic radiating surface pulsating in response to positive and negative hydraulic pressure impulses.

These and other objects of the invention will become more apparent from the ensuing description when taken with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic representation of the invention shown partially in cross section.

FIG. **2** is a schematic representation of a second embodiment of the invention also shown partially in cross section.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, an improved projector of acoustic energy **10** is depicted schematically below the surface of a body of water with water filling all voids and cavities throughout. Being completely flooded in this manner renders the projector relatively insensitive to ambient pressure variations and substantially identical operational characteristics remain irrespective of its operational depth. An impeller unit **11** draws in the water from the surroundings through an inlet port **11***a* and forcefully expels it to following elements via a section of flanged piping **12.**

An improved radiation assembly **15,** the exact makeup of which will be elaborated on later, receives the impelled water and channels it to a conical housing **25.** The downstream wall of the housing is provided with a plurality of radially extending apertures. Journaled onto this wall, a shutter unit **26** includes a disk **26***a* shaped with a plurality of radially reaching slots having dimensions corresponding to the apertures in the wall. The shutter unit further includes a heavy-duty bearing for providing rotational support for the disk.

As the disk is rotated, the apertures and slots become repetitively aligned and covered to interrupt the flow of water in an on-off sequence. Creation of the modulating on-off sequence is ensured by providing a cogged belt **27** mechanically engaging the disk and being driven by a variable speed motor **28.** A more thorough understanding of the mechanical configuration and coaction of the conical chamber, shutter unit and variable speed motor as they function to modulate the flow of impelled water will be gleaned from the above-identified U.S. Pat. No. 3,704,443. The only differences between this invention and the device of U. S. Pat. No. 3,704,443 is that this invention employs a cogged belt **27** for driving the disk **26***a* and includes a more heavy duty bearing in the shutter unit **26.** Otherwise there is substantial identity between the shutter units.

Referring once again to the radiation assembly **15,** its improved design enables reliable projection of low-frequency acoustic energy by transmitting negative hydraulic pressure impulses, as well as, positive hydraulic pressure impulses to an elastic or flexible envelope **16.** The envelope optionally is selected from one of a number of resilient sheets which, when filled with water assumes the configuration of an elastic sphere. As the modulated flow sequence is created by the impelled water's passing through shutter unit, the spherically-shaped envelope pulsates responsively in a sequence of outward and inward motions. In the alternative, the envelope is selected from a an inelastic flexible material such as a tar impregnated canvas-like material tailored the same as that shown in FIG. **1.** However, if an inelastic flexible material is chosen, it need be slightly under-filled with water to allow responsive outward excursions.

In either case, the envelope is suitably secured at opposite extremes around a section of piping **17** which is joined at opposite ends to flanged piping **12***a* and housing flange **25***a*. From the opposite extremes of the section of piping **1**, the cross-sectional area is reduced by tapering walls **18.** These walls are interconnected at a region of smallest cross-sectional area **18***a* and, when taken with the converging tapering walls, define a venturi **19.**

Since it is a well known fact that the pressure is reduced where the fluid rushes through a constricted, smallest cross-sectional area, slots **20** are provided coupling this area of reduced pressure to the envelope to draw in the envelope as fluid flows through the venturi. Thus, a plurality of slots **20** in the smallest cross-sectional area of **18***a* of the venturi section couple and transmit negative hydraulic pressure impulses to the envelope as impelled water flows through piping **17** and shutter unit **12.** Positive hydraulic pressure impulses are transmitted via the slots when the impelled water is blocked from flowing through the shutter unit. These negative and positive hydraulic pressure impulses impart responsive reciprocal displacements to the envelope in response to the interrupted water flow in the shutter unit. It has been found expedient to provide a mesh-like net **21** to prevent excessive sagging of the envelope **16** while it is being filled with water. Only one-half of the net is shown in the drawings for the sake of simplicity.

Another embodiment of the invention is depicted in FIG. **2.** Like elements are described with like reference characters to indicate their substantial identity; however, modifications in a modified radiation assembly **15***a* are so fabricated to provide a more rugged energy converter. An essentially tubularly-shaped element **22** is secured at opposite lateral extremes **22***a* and **22***b* on the outer surface of section of piping **17.** The tubularly-shaped element encloses the entire venturi section **19** and plurality of slots **20** to channel positive and negative hydraulic pressure impulses, created as described above, through its open opposite ends **22***b*.

A pair of cup-shaped dome members **23** fit down about the outwardmost portions of the open-ended tubular element and a pair of interposed annular-shaped wear strips **24** serve the purpose of sealing interior **23**a as well as providing a relatively friction-free surface on which the domes rest as they undergo their reciprocal excursions. The wear strips need not provide perfect sealing since nominal leakage in either direction will not degrade the performance of this embodiment. The domes are not retained by any additional structure although a retaining ring, not shown, could be included to keep the domes on the tubular element when the transducer is idle.

The negative and positive hydraulic pressure impulses alone determine the limits of the inward and outward excursions of the domes on the tubularly-shaped element. A designer will tune the system selecting the proper flow rates, internal dimensions of the venturi section and rotational speeds for the shutter unit to create negative and positive hydraulic pressure impulses which offset each other to reciprocate the domes within preestablished limits on the tubular element.

An improved hydroacoustic transducer fabricated in accordance with the above teachings projects acoustic energy as a function of flow rate. Increasing the flow rate increaes the level of projected energy. Variation of the rotational speed of the shutter unit by the variable speed motor allows selective variation of the projected signal. Freely flooding the transducer's innards renders it nonresponsive to changes in ambient pressure. Finally, the absence of structure for biasing or retaining the reciprocating surfaces, while simplifying the overall design, enables the responsive transmission of acoustic energy.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings, and, it is therefore understood that within the scope of the disclosed inventive concept, the invention may be practiced otherwise than specifically described.

What is claimed is:

1. In a transducer of acoustic energy having a motor pump unit drawing in water from the immediate surroundings for impelling the water and a rotary water chopper unit for sequentially interrupting the flow of the impelled water and for expelling the impelled water back to the immediate surroundings, an improvement therefor is provided comprising:

a venturi section provided with at least one slot interconnecting the motor pump unit and the water chopper unit for increasing the flow rate of impelled fluid therethrough creating negative hydraulic pressure impulses when said water chopper unit allows said flow of impelled fluid and positive hydraulic pressure impulses when said flow is interrupted. and

means in fluid communication with said slot for being bidirectionally displaced in response to the positive and negative hydraulic pressure impulses to project representative acoustic energy.

2. A transducer according to claim **1** in which the bidirectionally displaced means is formed of at least one panel of flexible material being outwardly and inwardly flexed upon receipt of said positive and negative hydraulic pressure impulses.

3. A transducer according to claim **1** in which the bidirectionally displaced means is an envelope of elastic material pulsating in response to said positive and negative hydraulic pressure impulses.

4. A transducer according to claim **3** in which said bidirectionally displaced means further includes a wire mesh covering for protecting the elastic envelope from envirionmental abuses and excessive said positive hydraulic pressure impulses.

5. A transducer according to claim **1** in which the bidirectionally displaced means includes,

a tubularly-shaped element in fluid communication with said slot,

a cup-shaped radiation dome coaxially disposed on said tubularly-shaped element and in fluid communication with said slot, and

at least one annular wear-strip interposed between said tubularly-shaped element and said radiation dome for ensuring responsive reciprocal excursions of said radiation dome in response to said positive and negative hydraulic pressure impulses.

6. A transducer according to claim **5** in which said tubularly-shaped element mounts a separate radiation dome at opposite axial extremes with a separate interposed annular wear strip for each dome for imparting simultaneous opposed reciprocal excursions in response to said positive and negative hydraulic pressure impulses.

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