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Myers

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[54] **COMPOUND HYDRAULIC SEISMIC SOURCE VIBRATOR**

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[21] Appl. No.: **265,428**

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[51] **Int. Cl.**[4] **H04R 23/00**

[52] **U.S. Cl.** **367/142;** 367/143; 367/174; 181/120

[58] **Field of Search** ..... 367/143, 174, 142; 181/110, 120, 402; 91/530, 167 R; 92/65

[56] **References Cited**

U.S. PATENT DOCUMENTS

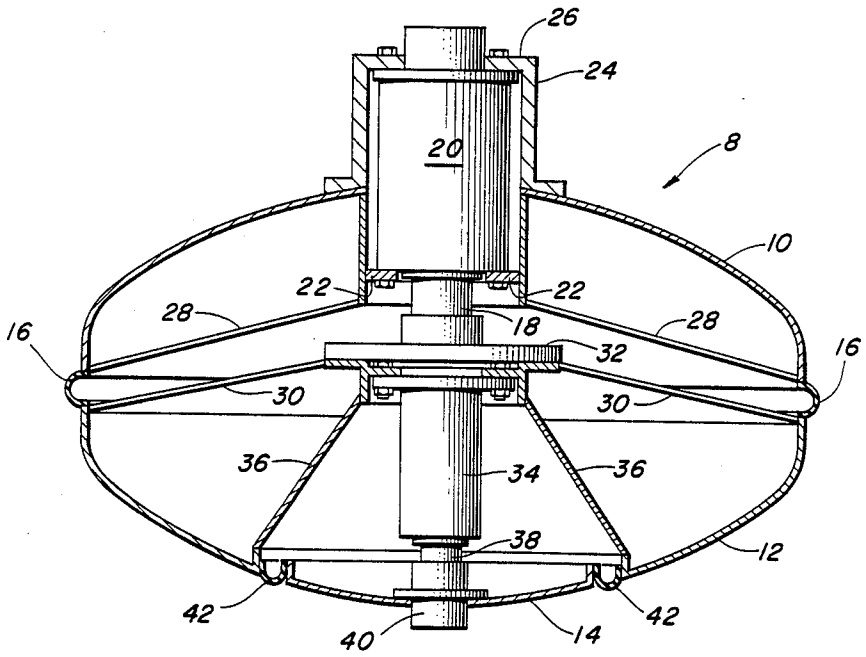
3,653,298	4/1972	Bilodeau	92/65
3,676,840	7/1972	Bays	340/12
4,139,733	2/1979	Falkenberg	381/202
4,741,246	5/1988	Padarev	91/530

Primary Examiner—Deborah L. Kyle
Assistant Examiner—J. Woodrow Eldred

[57] **ABSTRACT**

A seismic source marine vibrator having compound hydraulic cylinders for high and low frequencies is used to generate both low frequency and high frequency acoustic pulses. Low frequency pulses are generated by operating a low frequency radiating surface and a high frequency radiating surface simultaneously. High frequency pulses are generated by operating the high frequency radiating surface alone.

22 Claims, 2 Drawing Sheets



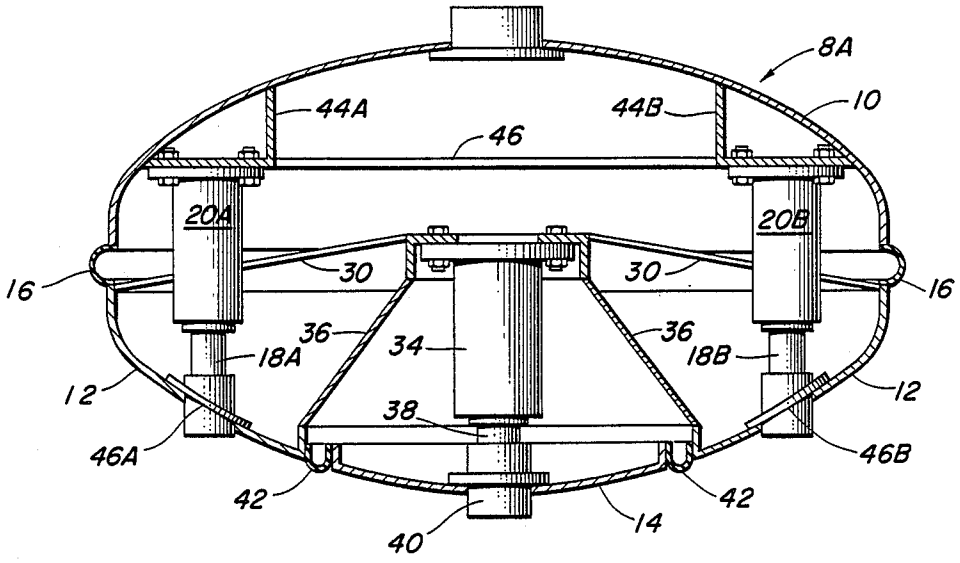


FIG. 2

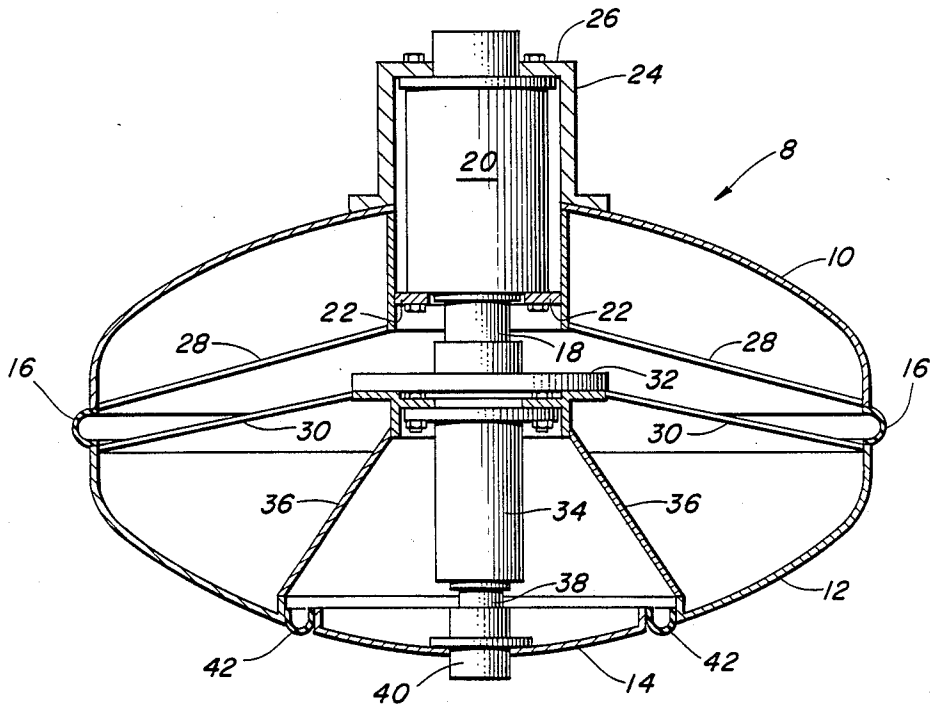


FIG. 1

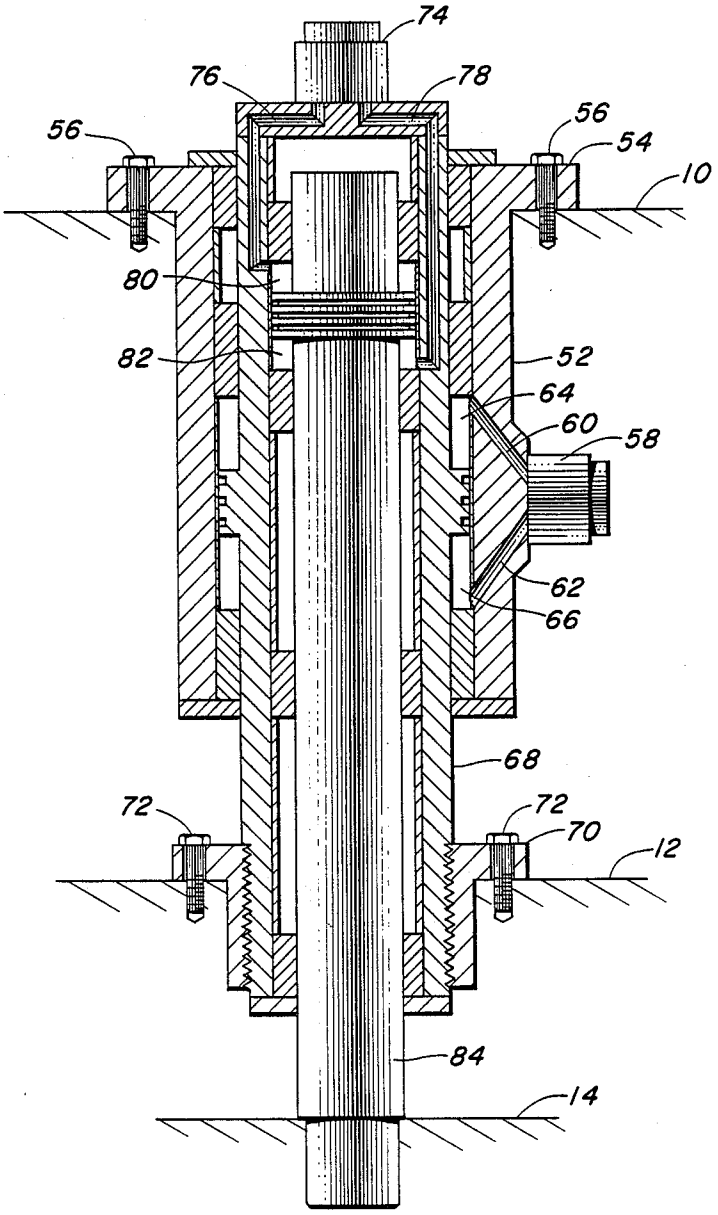


FIG. 3

COMPOUND HYDRAULIC SEISMIC SOURCE VIBRATOR

CROSS REFERENCE TO RELATED APPLICATION

This application is related to co-pending U.S. patent application Ser. No. 265,601 entitled "Multiple Frequency Range Hydraulic Actuator" (ICR 8139) filed concurrently herewith.

BACKGROUND OF THE INVENTION AND RELATED ART

The present invention relates to marine seismic exploration, and more particularly to marine seismic exploration in which a seismic source is coupled to the ocean floor to generate acoustic pulses.

In present seismic exploration, acoustic pulses are generated by seismic sources, propagate through the earths crust, are reflected by subsurface interfaces and detected upon the return to the surface. In marine exploration, seismic sources have taken the form of explosive charges and airguns. However, both of these types of seismic sources have had deleterious effects on marine life. As a result, a hydraulic vibrator had been developed. The hydraulic vibrator used in marine exploration is similar to that used in land based seismic exploration. This type of seismic source has been found to have less deleterious effects on marine ecosystems.

In seismic pulse generation, it is beneficial to be able to generate pulses over a wide frequency range. In this regard, the use of hydraulic vibrators includes a problem in the range of frequencies generated. In general, a hydraulic vibrator system includes a hydraulic power plant, a hydraulic cylinder, hydraulic circuitry and structural members designed to operate over a range of frequencies. Stroke and flow requirements for low frequency operation necessarily are exclusive of high frequency operation due to their size and mass. Similarly, stroke and flow design requirements concommitant with high frequency propagation exclude the applicability of these vibrator systems from use in low frequency systems.

PRIOR ART

An example of an early type hydraulic vibrator system is described in U.S. Pat. No. 3,392,369 titled "Fluid-Actuated Dual Piston Underwater Sound Generator" issued to J. A. Dickie et al. In the patent, two similarly sized sound radiating pistons are driven by hydraulic actuators in unison. The pistons are arranged as a pair of oppositely outwardly facing elements on opposite sides of the stationary housing and are sealed to the housing by flexible rubber gaskets. The actuator is adapted to move each piston in the direction opposite to that of the other at any particular time. As the pistons move out changing the external volume of the transducer, the internal space is filled with a gas under pressure. The apparatus described in this patent is designed to operate at low frequencies so that the sound waves which are generated under water have low attenuation.

U.S. Pat. Nos. 3,329,930 and 3,394,775, both entitled "Marine Vibration Transducer" issued to J. R. Cole et al. also describe hydraulic seismic source generators. U.S. Pat. No. 3,329,930 relates to a vibrational transducer that is driven at a controlled rate, two-part vibration by driving a piston vertically, reciprocally against the water medium. In this patent, a single piston is used in conjunction with a single actuator. U.S. Pat. No. 3,394,775, which is a continuation in part of U.S. Pat. No. 3,329,930, introduces a vibrational transducer unit which consists of two pistons attached to a cylinder and a piston rod. A flexible rubber cylinder or boot is slipped over these two pistons and securely fastened to each so that air which is trapped between the pistons cannot escape into the water nor can water flow into the air chamber. The reciprocating piston imparts a pressure wave into the water while the innerhousing areas within the rubber enclosure are isolated and maintained at a predetermined air pressure such that maximum coupling of vibrational energy into the water medium is provided.

U.S. Pat. No. 3,482,646 titled "Marine Vibrator Devices" issued to G. L. Brown et al. is a single piston, single actuator type of assembly similar to that of the U. S. Pat. No. 3,392,369. A pair of shell-like housing members are disposed generally in parallel and are flexibly sealed between the respective outer peripheries to define an interior air space. A drive means is contained within the air space and connected to the respective housing members to impart reciprocal movement to one housing member with respect to the other.

Additional hydraulic seismic source generating systems are described in U.S. Pat. No. 4,103,280, titled "Device for Emitting Acoustic Waves in a Liquid Medium" issued to Jacques Cholet et al., U.S. Pat. No. 4,211,301 titled "Marine Seismic Transducer" issued to J. F. Mifsud, U.S. Pat. No. 4,294,328 titled "Device for Emitting Acoustic Waves in a Liquid Medium by Implosion" issued to Jacques Cholet et al. and U.S. Pat. No. 4,578,784 titled "Tunable Marine Seismic Source" issued to J. F. Mifsud.

However, as stated previously, all of the foregoing hydraulic vibrator systems share a common problem. That is, none of the foregoing systems are capable of operating over a wide range of frequencies but in general, are limited to acoustic pulse generation in the low frequency range.

SUMMARY OF THE INVENTION

The present invention provides a hydraulic seismic source vibrator which is directed to solving the problems presented by prior art hydraulic seismic source vibrators. The present invention consists basically of an upper housing, a low frequency radiating surface, a low frequency hydraulic cylinder, a high frequency radiating surface, and a high frequency hydraulic cylinder. In operation, the low frequency pulses are generated through the operation of the low frequency radiating surface to which the high frequency radiating surface is connected. When low frequencies are to be generated, both the low frequency surface and the high frequency surface are operated in conjunction to provide the effect of one large low frequency radiating surface. The physical combination of the low frequency radiating surface with the high frequency radiating surface generates acoustic pulses having a frequency range from low frequencies to a mid range. For the operation in the higher frequency range, the high frequency radiating surface operates alone. In doing so, the high frequency radiating surface can provide acoustic pulses having frequencies from the mid range to high frequencies, which have not been attained by hydraulic vibrator systems previously.

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