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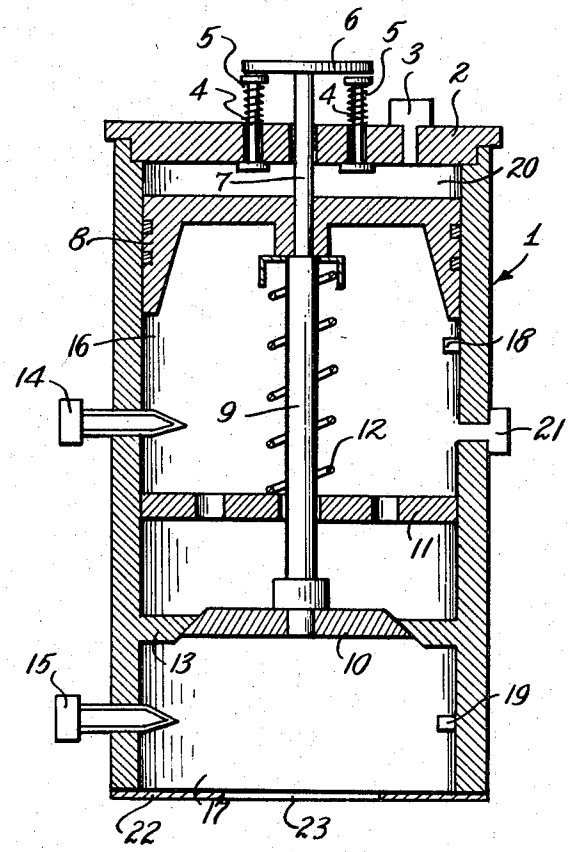

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PROCESS FOR THE PRODUCTION OF MACHINE-MADE WAVES AND APPARATUS FOR PRACTICING THIS PROCESS

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ABSTRACT OF THE DISCLOSURE

Seismic waves are produced in a chamber divided by a movable wall into a normally closed compartment and a compartment open to the exterior environment by injecting under pressure into both compartments a combustion supporting gas and a predetermined quantity of combustible fluid while the movable wall is closed, and then igniting the mixture in the compartment open to the exterior environment a fraction of a second before opening the movable wall for placing the two compartments in communication so that the combustible mixture in the normally closed compartment is ignited by the combustion taking place in the compartment open to the environment. The ignition of the two combustible mixtures in rapid succession produces the desired seismic wave. The movable wall is actuated by compressed air introduced into a chamber behind a piston operably connected with the movable wall, the compressed air being vented from the chamber through vent valves opened by a member carried by the piston.

The present invention relates to a process for the emission of machine-made waves and to apparatus for the operation of this process.

Generators for the production of machine-made waves are well known and the existing generators can be separated into two categories:

(a) The first are gas cylinders in which a reservoir filled with a mixture of combustible gas and combustion-supporting gas is ignited. Combustion causes a pressure wave which can spread into a continuous medium. This system presents various drawbacks; first, the pressure wave occurs in a closed or partially closed chamber. As a result the pressure wave is strongly attenuated by the walls of the chamber which leads to a very indistinct output. This system which calls for a combustible gas and for a combustion-supporting gas requires for its fueling heavy and cumbersome containers for confining these compressed gases. Finally, the optimum performance of this system is dependent on the proportions of a gaseous mixture which is difficult to maintain because the system involves an opening for the escape of gas.

(b) The second category comprises compressed air cylinders in which a gas such as air is compressed, and then caused to expand abruptly. This system involves the inconvenience of only using the energy manufactured by expansion without applying additionally the pressure caused by a combustion. Furthermore, the system has a rather weak output because of the very limited surface of contact between the air and the surrounding medium, resulting in a limited cone of propagation. The pressure wave attenuates itself very rapidly if produced in the medium of a hydrostatic environment, the energy being dissipated.

The process of the present invention overcomes the

difficulties cited hereinabove by using a combination of several means.

The process according to the present invention consists of injecting under pressure a combustion-supporting gas into a closeable compartment of a chamber having a normally closed movable wall capable of being opened, and which, when closed, separates the said chamber into first and second compartments, the first of which is in open communication with the exterior environment and the second being the closeable compartment, injecting a predetermined quantity of combustible fluid into each of the two compartments, inducing combustion of the mixture in the first compartment and opening at a predetermined moment the movable wall thus placing the two compartments in communication.

In one species of practice according to the invention, the combustion is also caused in the second compartment at a predetermined time interval after the two compartments are placed in communication.

According to one characteristic of the present invention the opening of the movable wall is controlled by the injection of air on the rear surface of a piston connected to the movable wall.

According to a preferred feature of the present invention, the combustible substance injected into the first compartment is in an amount clearly higher than what is necessary for the combustion.

The present invention also involves an apparatus for the operation of this process.

The apparatus according to the present invention comprises a chamber in which is mounted a piston that is rigidly connected with a valve element, this valve element separating the chamber into two compartments, one closed by the said valve element and the other in open communication with the outside atmosphere, the two compartments being each provided with an injector connected with one or more pumps capable of assuring the supply of combustibles to the two compartments, with vents provided for the introduction of air, with means to assure the displacement of the piston-valve assembly, and with means to initiate the combustion of the mixture of combustible and combustion-supporting fuel previously provided.

In a preferred embodiment of the apparatus according to the invention the chamber comprises a supplementary compartment at the rear of the piston that is connected with the valve element, the said supplementary compartment being provided with vents for the introduction of air and with valves for evacuation of this air at a given moment.

In one embodiment of the apparatus, the control of evacuation of the supplementary compartment is actuated by a stem extending from the piston, this stem causing the opening of the latter valves.

A description of one embodiment of the invention will be given with reference to the single figure of the drawings.

A cylinder **1** is defined by a wall **2** in which are arranged ducts **3** for the introduction of air under pressure. One or more valves **4** also extend through this wall, these valves being provided with return springs **5** and being opened by actuation of a disc **6** fixed to a stem **7**, which stem is rigidly connected to a piston **8** which is displaceably positioned in the interior of the cylinder **1**. On this piston is fixed a stem **9** rigidly secured to a large-diameter valve **10**. A guide **11** permits the stem **9** to reciprocate freely while being guided thereby. Furthermore this guide **11** serves to support a spring **12** which tends to react toward the bottom of the cylinder, the piston **8** thereby assuring the closure of the valve **10** by engagement with a seat **13** fixed in the cylinder **1**. An injector

21 is provided for injecting under pressure a combustion supporting gas into compartment 16. Injectors 14 and 15 are provided for the injection into the two compartments 16 and 17 of a combustible such as, for example, a mixture of hydrocarbons currently identified by the name of "gas oil." Means 18 and 19 are provided to provoke the explosion of the mixture situated in the compartments 16 and 17. The back face of the piston defines a supplementary compartment 20 into which one can inject air under pressure.

The operation of the apparatus described above is as follows: air under pressure is injected through injector 21 into the compartment 16; this air is injected under a pressure which can range from 1 to 100 bars. In the actual operation of the apparatus we have used a pressure of 8 bars. The pressurizing of this compartment retracts the piston 8 which causes, due to the difference in cross-section, the closing of the valve 10 which thereby seals up the compartment 16. Air is injected under pressure into the compartment 17 through an injector, not shown, the said air being formed as a bubble on the free surface of the compartment 17; then, with the aid of injectors 14 and 15, the fuel is injected into compartments 16 and 17. Thereafter, one ignites the mixture in the compartment 17 by means of an igniter 19. The bubble which had begun forming itself while air was being injected, under hydrostatic pressure for example, is further developed by the addition of volume caused on one hand by the combustion of the mixture and on the other hand by the increase in temperature. This flame spreads slowly hanging beneath the bottom of the bubble and volatilizing the excess combustible material. At this moment air under pressure is injected into the supplementary compartment 20 through ducts 3 which causes a retraction of the piston 8 and opening thereby of the valve 10. The mixture of combustible and combustion-supporting material in compartment 16 issues through the open valve during combustion in the compartment 17 and thereby permits the original flame to spread thereinto and to react against the environment continuously present before it. A very strong blast is therefore established by the original flame, which results in providing a significant exchange surface between the wave generator and the adjacent atmosphere into which these manufactured waves should spread, which causes a strong release of energy for a brief period. At the end of the stroke of the piston, the piston through the agency of the transverse member 6 pushes open the valves 4 to thereby evacuate from supplementary compartment 20 the air which was confined therein. Under the influence of the spring 12 the piston returns to its original position, the valves 4 again closing the supplementary compartment 20; the valve 10 returns to its seated position and is again ready to start a new cycle. The rhythm of wave emission is on the order of 0.1 to 50 strokes per minute. In tests conducted with the apparatus according to the invention, we hape operated for long periods at a frequency of 8 strokes per minute.

The significance of this apparatus relates to the fact that the manufactured waves which are emitted by the device do not produce oscillations in the liquid medium, oscillating known as the bubble effect, and particularly related to the points of reentry determined when one plots the diameter of the bubble as a function of the time no longer existing, the diameter of the bubble being represented as a function of the time by a sinusoid. One can, in particular, with the help of this apparatus emit manufactured waves into a liquid medium without creating disturbances and in particular without significant parasitical oscillations from the mass of air, in the emission of the manufactured waves.

The process according to the invention can be practiced not only with the apparatus described above but also with other apparatus in which the gas produced by causing an explosion or a rapid combustion in a compartment open to the exterior environment are pushed by causing the gas provided by a second explosion in a second compartment in communication with the first compartment at a preselected moment.

In particular, surprising results have been attained with the process of this invention by causing the first combustion or explosion in the first compartment 200 to 300 milliseconds before opening the valve that shuts off the second compartment. A quantity of gas oil is injected into the first compartment that is ten times greater than what is necessary for the combustion.

We have thereby been able to readily observe the reflections of manufactured waves on feebly reflecting horizons positioned at a depth of about 5,000 meters, the explosion being realized in the ocean at a depth of 100 meters.

The process is also usable for seismic prospecting on land.

In another modification more significant pressures range between 50 and 500 bars are used. In the first combustion compartment the pressure, after ignition of the mixture, increases to a value approximately five times higher so that emission of the gas takes place at pressures that can attain and surpass 1,000 bars. The emission may be further augmented by providing the base of the compartment 17 with a diaphragm 22 leaving a surface in the form of an opening 23 for the passage of gas ranging from 5 to 50 percent of the section of the compartment. The speed of passage of the gas is thereby augmented and the transmitted energy is still more significant.

We claim:

1. Process for the production of seismic waves which comprises the steps of injecting under pressure a combustion supporting gas into a normally closed compartment of a chamber having one movable wall which, when closed, divides the said chamber into two adjacent compartments and which can be opened to provide communication between the normally closed compartment and the other compartment which is opened to the exterior environment, injecting under pressure a predetermined quantity of combustible fluid into both compartments to provide therein a combustible mixture, igniting the combustible mixture in the compartment opened to the exterior environment thus forming a bubble, and opening the movable wall during combustion in the compartment opened to the environment thus placing the two compartments in communication thereby igniting the combustible mixture from the normally closed compartment by the combustion taking place in the compartment open to the environment and injecting it into the bubble for expanding and heating said bubble and separating it from the said chamber.

2. Process in accordance with claim 1 including the step of effecting ignition in the normally closed compartment at a predetermined instant after opening of the movable wall.

3. Process according to claim 1 in which the combustible fluid injected into the compartment open to the exterior environment is in an amount substantially in excess of what is necessary for combining with the combustion supporting gas contained therein.

4. Process according to claim 1, in which the combustible fluid used in is a combustible liquid.

5. Apparatus for conducting the operation of a process for producing seismic waves, comprising: a chamber having a movable wall capable of being opened, the said movable wall separating the said chamber into two adjacent compartments, one of which is in communication with the exterior environment and the other of which is normally closed by said movable wall, means for injecting under pressure a combustion supporting gas into both of said compartments, means for injecting a combustible fluid into each of the two compartments, means for igniting the combustible mixture in the compartment which is

in communication with the exterior environment, means for operating the movable wall to place the two compartments in communication at a predetermined instant after the means for initiating combustion in the compartment in communication with the exterior environment has been actuated.

6. Apparatus in accordance with claim 5 wherein said apparatus comprises a piston slidably mounted in the normally closed compartment and operably connected with said movable wall, the head of the piston together with a wall of the normally closed compartment forming a supplementary compartment, said supplementary compartment being provided with vents for feeding air under pressure therein for actuating said piston and with valves to assure the evacuation of this air at a predetermined instant.

7. Apparatus according to claim 6 in which the control of the evacuation of air from the supplementary compartment is assured by a stem fixed to the piston, said stem being arranged to open said last mentioned valves.

8. Apparatus in accordance with claim 5 wherein the compartment which is in communication with the exterior environment is provided with a diaphragm the free surface of which comprises between 5 and 50% of the section of the compartment.

9. Apparatus in accordance with claim 5 including means for initiating combustion in the normally closed compartment following the opening of the movable wall.

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