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D. E. HOLCOMB, JR

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SHOCK WAVE GENERATOR HAVING A SHOCK WAVE CONTROLLER

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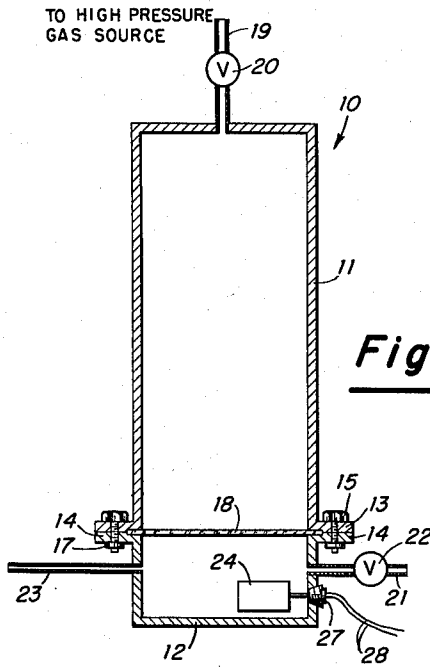


Fig. 1

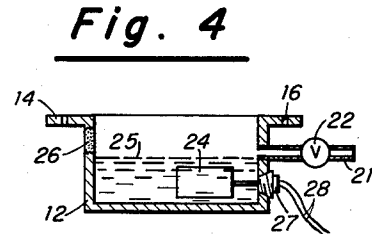


Fig. 4

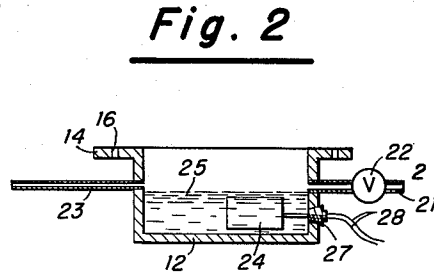


Fig. 2

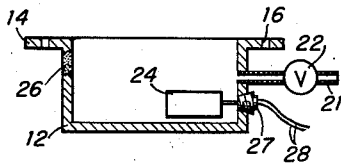


Fig. 3

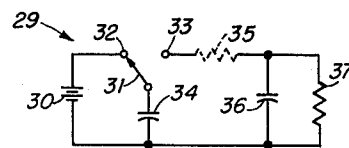


Fig. 6

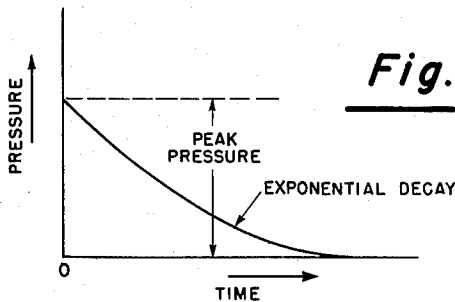


Fig. 5

INVENTOR.
DONALD E. HOLCOMB, JR.
BY *George Siplin*
George E. Pearson
ATTORNEYS

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SHOCK WAVE GENERATOR HAVING A SHOCK WAVE CONTROLLER

Donald E. Holcomb, Jr., San Diego, Calif.

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12 Claims. (Cl. 73—12)

(Granted under Title 35, U.S. Code (1952), sec. 266)

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.

The present invention relates to a shock wave generator and more particularly to an improved shock wave generator capable of producing controlled simulated explosive shock waves in a gas or liquid which approximate the peak pressure and exponential decay of true explosive shock waves.

This invention has a wide range of prospective applications such as the testing or calibration of pressure instruments or to test materials or equipment.

Heretofore, devices constructed for this purpose required the detonation of an explosive charge in a gas or in a liquid. This often required impractical charge sizes in order to obtain the desired peak pressures or decay time. Moreover, earlier devices did not provide means for controlling the decay of the shock waves nor for their transmission into a liquid.

The shock wave generator illustrative of this invention consists of a gas storage chamber, an expansion chamber, a gas tight, frangible diaphragm dividing the expansion chamber from the storage chamber and an acoustic impedance consisting of either a long tube of small diameter or a porous plug leading from the expansion chamber to the outside atmosphere. In a modification of the invention, where behavior of the waves is to be studied in a liquid, an expansion chamber containing liquid is provided.

It is an object of this invention to provide an improved shock wave generator.

Another object is to provide a shock wave generator which generates simulated explosive shock waves whose peak pressures and decay times can be controlled.

A further object of the invention is the provision of a shock wave generator wherein the peak pressure of the generated shock waves can be controlled.

Still another object is to provide a shock wave generator wherein the decay of the generated shock waves can be controlled such that the decay will approximate the exponential decay of true explosive shock waves.

An additional object of the present invention is the provision of a shock wave generator wherein generated shock waves can be transmitted for study of their behavior in a liquid.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 is a vertical cross-sectional view of the shock wave generator;

Fig. 2 illustrates a vertical cross-sectional view of the expansion chamber of the device showing a modification thereof;

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Fig. 3 shows a cross-sectional view of the expansion chamber illustrating still another modification thereof;

Fig. 4 shows a cross-sectional view of the expansion chamber showing still a further modification thereof;

Fig. 5 shows a graph setting forth the approximate pressure versus time relationship of the shock waves generated by the device in air or liquid; and

Fig. 6 shows an electrical circuit analogous to the shock wave generator of the present invention.

Referring now to the drawings, wherein like reference characters designate like or corresponding parts throughout the several views, there is shown in Fig. 1 a shock wave generator 10 having a gas storage chamber portion 11 and an expansion chamber portion 12. The chamber portions 11 and 12 are formed with end flanges 13 and 14, respectively, each having mutually registering holes 16 adapted to receive bolts 15. Nuts 17 are adapted to engage the bolts 15, thus providing a means for fastening together the chamber portions 11 and 12 to form a container. A gas tight, frangible diaphragm 18 is suitably positioned between the chamber portions 11 and 12 such that it is held in fixed position by the flanges 12, 13, bolts 15 and nuts 17, to form a breakable seal between the chamber portions 11 and 12. Chamber portion 11 is further provided with a conduit 19, having a valve 20, adapted to be connected to a high pressure gas source (not shown). Chamber portion 12 is further provided with a conduit 21 and a valve 22 leading to the atmosphere, and a long tube of small diameter 23 also leading to the atmosphere. The object under test or calibration 24 is positioned in the expansion chamber 12 as by a supporting plug 27 inserted into a wall of the expansion chamber. Wires 28, sealed in the plug 27 are adapted to be attached to the object 24 and lead to an indicating system (not shown).

Fig. 2 shows the expansion chamber 12 having the test object 24 immersed in a liquid 25.

Fig. 3 discloses an expansion chamber 12, similar to that shown in Fig. 1, having an acoustical impedance consisting of a porous plug 26.

Fig. 4 discloses the expansion chamber 12 of Fig. 3 wherein the test object is immersed in a liquid.

Obviously, the storage and expansion chamber portions 11 and 12 may be fashioned from suitable material into any desired form, preferably the storage chamber portion 11 having a substantially greater volumetric capacity than the expansion chamber portion 12, since it is desirable to subject the test object to a substantially instantaneous peak pressure which approximates the pressure selected to be developed in the storage chamber portion, a condition possible only when one chamber is larger than the other.

The frangible diaphragm 18 could be fashioned out of any desired material such as glass, plastic, metal, or the like and of any suitable thickness. Selection of the diaphragm of a particular material and thickness ultimately depends on the peak pressures employed in the apparatus. For example, if it is desired that the peak pressure developed in the device be of the order of 1500 p.s.i., a diaphragm of such characteristics is used which will fracture at this pressure. However, if a mechanical means (not shown) is employed to break, cut, shatter or otherwise destroy the diaphragm after the desired peak pressure in the device is achieved, a diaphragm should be selected which is capable of withstanding the full range of contemplated peak pressures.

One form of acoustic impedance employed in this invention consists of a long tube of small diameter 23, Figs. 1 and 2, or a plug 26, Figs. 3 and 4. If the tube is used, the impedance offered to gas flow thereby would be proportional to the length and cross-sectional area of

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the tube. Accordingly, the longer the tube and the smaller the cross-sectional area, the greater the impedance to gas flow, and consequently a longer decay time of the pressure in the system. On the other hand, if the porous plug 26 is used, any material having porous qualities, such as felt or the like, may be employed in the plug to produce the desired acoustic impedance.

The operation of the device will now be explained in detail. The material or instrument to be tested 24 is supported in the expansion chamber 12 by means of the supporting plug 27. Valve 20 is opened, thereby admitting gas under pressure into the storage chamber 11 until the pressure developed therein breaks the diaphragm 18 and escapes into the expansion chamber 12, rapidly raising the pressure therein to a peak value, as shown in Fig. 5. The gas then escapes through the pipe 23, Fig. 1, or the porous plug 26, Fig. 3, both of which offer resistance to gas flow, resulting in a decrease in gas pressure with time inside the system, which approximates the exponential decay shown in Fig. 5 and finally approaches that of the outside atmosphere upon completion of the operation, valve 22 may be opened to permit any residual gas pressure to escape to atmosphere through conduit 21.

In the modifications shown in Figs. 2 and 4, the pressures developed in the expansion chamber 12 above the liquid are transmitted to the liquid in the form of pressure waves.

The operation of the shock wave generator may be compared to the operation of the electrical circuit 29 of Fig. 6 to which it is analogous and wherein there is shown a battery 30 which is analogous to the source of pressure (not shown) of the shock wave generator, a switch 31 in position 32, corresponding to the diaphragm 18 in its unshattered state, a position 33 of the switch 31 corresponding to the broken diaphragm 18, a condenser 34 analogous to the first chamber portion 11, a resistance 35 corresponding to the negligible resistance of the broken diaphragm 18, a condenser 36 analogous to the chamber portion 12, and a resistor 37 corresponding to the acoustical impedance of either the pipe 23 or the plug 26.

It can be readily seen that when switch 31 is placed in position 32 the voltage of the battery is directly applied to the condenser 34 resulting in the condenser charging to the battery voltage. Accordingly, the voltage built up across condenser 34 may be compared to the pressure of the gas built up in the chamber portion 11 of the shock wave generator before the diaphragm 18 is shattered.

Movement of switch 32 to position 33 substantially instantaneously places the voltage on condenser 34 across condenser 36, the resistance 35 being negligible and the condenser 36 being substantially smaller in capacitance than condenser 34 and results in a voltage across both condensers which approximates the voltage on condenser 34 prior to the movement of switch 32 to position. Thus, the switching to position 33 corresponds to the breaking of diaphragm 18, the resistance 35 corresponds to the negligible resistance of the shattered diaphragm 18, the voltage across both condensers 34 and 36 is analogous to the peak gas pressure within the shock wave generator immediately after breaking of the diaphragm and the difference in capacitance between the two condensers corresponds to the difference in volume of the two chamber portions 11 and 12.

Referring further to the electrical system, the voltage developed across both condensers also appears across the resistance 37. Current flows through the resistance 37, the energy stored in the condensers is dissipated and the voltage across the condensers and the resistance 37 decays exponentially approaching zero asymptotically. The greater the value of resistance 37 the longer the time of decay of the voltage. Resistance 37, accordingly, may be compared to either of the acoustical impedances 23 or 26, which act similarly to decay the peak pressure of the gas in the shock wave generator.

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Thus, it can be seen that a shock wave generator has been provided which generates simulated explosive shock waves whose peak pressure and time of decay can be controlled.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A shock wave generator comprising a container having a first chamber portion adapted to receive gas under pressure, a second chamber portion connected to said first chamber portion, a first control means mounted in said container for opposing and suddenly releasing gas pressure in said first chamber portion to said second chamber portion for substantially instantaneous buildup of said gas pressure to peak value throughout said container, and an acoustic impedance control means mounted in and constantly communicating said second chamber portion with atmosphere, said acoustic impedance control means being specially formed for effecting a regulated gas pressure release closely approximating the exponential decay rate of an explosive shock wave.

2. A shock wave generator as defined in claim 1 wherein the acoustic impedance control means includes a long pipe having a small diameter.

3. A shock wave generator as defined in claim 1 wherein the acoustic impedance control means includes a porous plug.

4. A shock wave generator comprising a container having a first chamber portion adapted to receive gas under pressure, a second chamber portion connected to said first chamber portion, a first control means having a frangible diaphragm mounted in said container for opposing and suddenly releasing gas pressure in said first chamber portion to said second chamber portion for substantially instantaneous buildup of said gas pressure to peak value throughout said container, and an acoustic impedance control means mounted in and constantly communicating said second chamber portion with atmosphere, said acoustic impedance control means being specially formed for effecting a regulated gas pressure release closely approximating the exponential decay rate of an explosive shock wave.

5. A shock wave generator as defined in claim 4 wherein the acoustic impedance control means includes a long pipe having a small diameter.

6. A shock wave generator as defined in claim 4 wherein the acoustic impedance control means includes a porous plug.

7. A shock wave generator comprising a container having a first chamber portion adapted to receive gas under pressure, a second chamber portion having some liquid therein and connected to said first chamber portion, first control means mounted in said container for opposing and suddenly releasing gas pressure in said first chamber portion to said second chamber portion for substantially instantaneous buildup of said gas pressure to peak value throughout said container, and an acoustic impedance control means mounted on said second chamber portion for regulating gas pressure suddenly released by said first control means whereby it decays exponentially with time.

8. A shock wave generator as defined in claim 7 wherein the acoustic impedance control means includes a long pipe having a small diameter.

9. A shock wave generator as defined in claim 7 wherein the acoustic impedance control means includes a porous plug.

10. A shock wave generator comprising a container having a first chamber portion adapted to receive gas under pressure, a second chamber portion having some liquid therein and connected to said first chamber portion, a first control means having a frangible diaphragm

mounting in said container for opposing and suddenly releasing gas pressure in said first chamber portion to said second chamber portion, and an acoustic impedance control means mounted on said second chamber portion for regulating gas pressure suddenly released by said first control means whereby it decays exponentially with time.

11. A shock wave generator as defined in claim 10 wherein the acoustic impedance control means includes a long pipe having a small diameter.

12. A shock wave generator as defined in claim 10 wherein the acoustic impedance control means includes a porous plug.

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