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B. E. DRIMMER

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DETONATION ARRESTER FOR LIQUID DETONABLE SUBSTANCES

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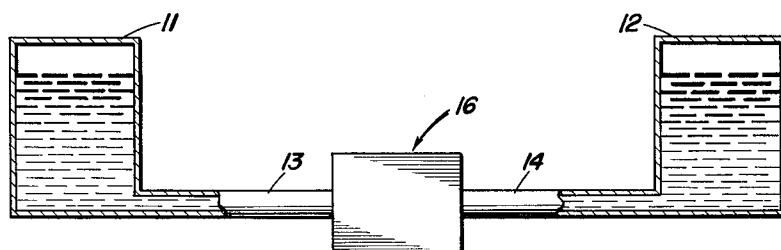


FIG. 1

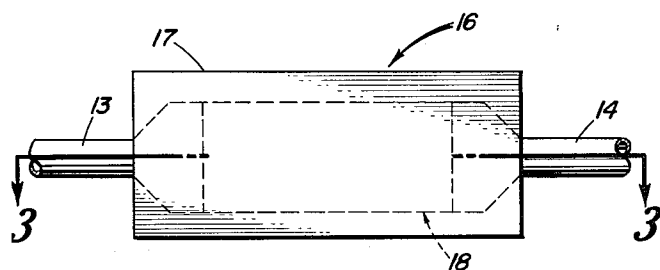


FIG. 2

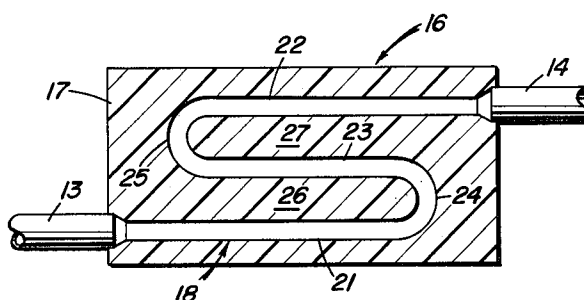


FIG. 3

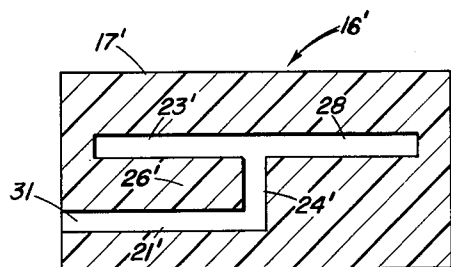


FIG. 4

INVENTOR.
Bernard E. Drimmer
BY *N. J. [Signature]*
ATTORNEY.
Frank B. Nieman AGENT.

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Bernard E. Drimmer, Silver Spring, Md., assignor to the
United States of America as represented by the Secre-
tary of the Navy

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11 Claims. (Cl. 102-1)

(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 detonation arrester in which dynamic compression is utilized to pre-compress an explosive to such density as to create an explosion barrier to destroy the explosive's ability to propagate a detonation.

Prior art devices generally utilized a plurality of small diameter channels to pass the explosive through. The diameter of each channel was less than a failure diameter of the explosive. This system required high hydrostatic pressure to force the liquid explosive through the channels which resulted in a substantial increase in the temperature of the explosive. The combination of high pressure and high temperature is a serious disadvantage in viscous or sensitive explosives.

The general purpose of this invention is to provide a method and apparatus of utilizing the inherent high pressure shock wave resulting from a detonation of an explosive or detonable fluid to prevent propagation of the detonation in the event of an undesired explosion. This shock wave is attenuated in a transmission medium and intercepts the undetonated liquid downstream from the travel of the explosion. This attenuated shock wave pre-compresses the fluid to such an extent that when the detonation reaches the pre-compressed fluid the detonation will fail to pass this zone due to the inability of the detonable fluid to detonate in that compressed state.

An object of the present invention is to provide a method for dynamically compressing an undetonated explosive fluid to a pressure region that will prevent propagation of detonation in that fluid, the compression resulting from the low pressure shock wave developed by the attenuation by transmission through an inert attenuating material, of the high pressure shock wave generated by the detonation of part of the explosive fluid itself.

A further object is to provide apparatus for transmitting and attenuating a high pressure shock wave generated by an explosion in a detonable fluid to an undetonated portion of the detonable fluid, downstream from the detonation front, to compress the undetonated liquid to a pressure domain which will not support detonation so that the oncoming detonation wave cannot propagate through this region thereby preventing propagation of the explosion beyond the compressed zone.

Other objects, advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawing wherein:

FIG. 1 illustrates a plan view of the detonation arrester placed between two tanks containing an explosive liquid;

FIG. 2 is an enlarged, top view of the detonation arrester showing the channels in dashed lines;

FIG. 3 is a sectional side view taken along lines 3-3 of FIG. 2 showing the symmetrical paths of the fluid flow channels; and

FIG. 4 is a schematic drawing of a test apparatus utilized to verify the principle of the invention.

This invention relates to fluid high explosives. Once a

detonation is initiated in such materials it travels through the undetonated portion as a chemically-reacting shock wave at a relatively uniform rate, which is generally from about 4,000 to 9,000 meters per second, each explosive species having a characteristic velocity. These shock waves, generated by the traveling explosion have peak pressures in the range of 100-300 kilobars which decrease rapidly in intensity as they pass through a surrounding inert medium.

A commonly known characteristic of high explosives is that the rate of detonation is essentially linearly dependent on the density of the explosive. It is not generally known that there is a limiting density, characteristic of each explosive, beyond which it will fail to propagate detonation. Compression of an explosive to a density beyond this value then will prevent its detonation.

If a traveling detonation were to arrive at a detonable high explosive fluid being compressed to this pressure region, where it is impossible to propagate a detonation, then the detonation would extinguish or quench itself due to the explosion barrier formed by the pre-compressed detonable fluid. The utilization of this principle, to deliberately prevent propagation of detonation, is the basic concept of this invention. A practical method for automatically developing a region of such pre-compression in the case of an accidental explosion is set forth herein-after.

If the density of the detonable fluid were to be increased still further by dynamic compression as for example by a shock wave, normal initiation of detonation would occur because of the increased importance of other mechanisms of initiation of detonation.

This shock pressure at which initiation occurs, varies with different explosives, and is generally characterized by the peak pressure, in kilobars, required to effect initiation in 50% of the samples of the particular explosive species. Typically, for military high explosives, for example, these pressures are in the range of 15 to 40 kilobars for solids, and 10 to 90 kilobars for liquids. Generally speaking, if the peak pressure were increased one or two kilobars over this 50% point, substantially all of the samples of the particular explosive would detonate. On the other hand, if the pressure were decreased, one or two kilobars from this 50% figure, substantially none of the test specimens would detonate.

If the value of the peak pressure required to initiate 50% of the explosive samples were divided by two, the resulting pressure would be in, or generally close to, the region at which the extinguishing or quenching of detonation for that explosive occurs. The exact boundaries of this particular pressure region cannot, at the present time, be expressed by a mathematical formula covering all fluid high explosives. The boundaries can only be expressed in terms of results experimentally determined for each explosive species.

Referring to FIG. 1 there is shown a first tank 11 containing a detonable fluid high explosive. A second tank 12 similar to the first tank is shown with connecting pipes 13 and 14 leading from the two tanks to a detonation arrester generally shown at 16. If a detonation were to accidentally arise in either one of the tanks or pipes it is highly desirable that the explosion be prevented from spreading to the other tank. This result is achieved automatically in the detonation arrester 16.

Referring to FIG. 2, there is shown the detonation arrester 16 with a portion of the pipes 13 and 14 connected thereto. The shock attenuator 17, of the detonation arrester 16 is a moldable material, such as plastic exemplified by linear thermoplastic methyl methacrylate polymer, also known as Plexiglas or Lucite, or a material such as plaster of Paris, or else it could be an enclosure con-

taining an inert fluid such as water, or some sawdust, or any other convenient shock attenuating material, not a gas. A plurality of channels generally shown at 18 are cut or formed within the material frame 17 and may be made of the same material as the connecting pipes or may be of the same material as the frame, if the material is suitable for containing a fluid.

FIG. 3 illustrates the channels 18 forming an S flow pattern through the shock attenuator 17. As will be noted from concurrently examining FIGS. 2 and 3, the pipes 13 and 14, upon joining the channels 18 change from a circular to a substantially rectangular cross-sectional area. The cross-sectional area of the channels 18 are equal to or somewhat greater than the cross-sectional area of the pipes 13 and 14, so that the flow of the liquid will not be significantly impeded within the arrester. The flow in pipes 13 and 14 can be bi-directional, and by symmetry, the detonation arrester is effective in extinguishing a detonation from either direction.

The detonation arrester 16 has first and second channels 21 and 22 for shock generation, and a channel 23 for shock receiving. The shock receiving channel 23 is connected on both ends to the two shock generating channels 21 and 22, by U-shaped bends 24 and 25. As noted before, the thin rectangular shaped channels 18 are completely imbedded in a suitable solid or liquid material. The material between the shock generating channels and the shock receiving channel functions as a shock-wave attenuation and transmission medium, and is further identified as first and second transmission mediums 26 and 27.

In operation the detonation arrester 16 does not impede to any significant extent the flow of the high explosive fluid, since the area of the channels 18 is equal to or greater than the cross-sectional area of the connecting pipes 13 and 14. This eliminates the necessity of significantly increasing the pressure to maintain proper fluid flow or the danger of increasing the temperature of a sensitive high explosive by passing it through constrictive openings. To explain the operation of this invention, imagine an accidental detonation developing in tank 11 or pipe 13, FIG. 1. The detonation would proceed through the tank, down the pipe 13, and enter the arrester 16, shown in FIG. 3. Proceeding through channel 21, the detonation would cause a shock wave to propagate through the transmission medium 26. As the shock wave travels through the transmission medium it would be greatly attenuated by the time it impinges upon the shock receiving channel 23. The arrival of the shock wave at the shock receiving channel 23 would pre-compress the detonable fluid contained within this channel to a pressure region in which the fluid explosive cannot propagate the detonation. The detonation, traveling through channels 21 and 24, collides with the pre-compressed fluid very close to the junction of channels 24 and 23. Unable to propagate through the region of pre-compression there, the detonation quenches out, preventing propagation into tank 12, FIG. 1.

Since the velocity of propagation and attenuation of shock waves through the transmitting medium are known or can be readily measured, and since the detonation velocities are also known, then the thickness of transmission mediums 26 and 27 can be designed to produce the desired level of pre-compression. Thus the liquid detonable explosive within shock receiving channel 23 can be automatically placed in the desired level of pre-compression when the explosion front arrives in the shock receiving channel 23.

The only limitation on the shock transmitting medium is that it cannot be a gas, since the explosive front of the detonation might shatter the shock transmitting channel 21. If a piece of the fragmented shock transmitting channel 21 were to strike the shock receiving channel 23, the impact of the flying fragment might be sufficiently

strong to initiate a detonation within the shock receiving channel 23 before the pre-compression mechanism sets in. With the use of a solid or liquid transmission medium, fragmentation is delayed, and the transmitted shock wave can be attenuated to the proper pressure region of pre-compression of the detonable liquid.

The operation has been explained on the assumption of an explosion in tank 11 or pipe 13 of FIG. 1. The same end result would be obtained if an explosion were to occur in tank 12 or pipe 14, since the same set of operations would occur, except in the opposite direction of travel, due to the symmetrical layout of the detonation arrester.

Experimental verification of the principle utilized in the present application has been obtained by the apparatus shown schematically in FIG. 4. Some of the reference numerals applied to the apparatus of FIG. 4 correspond to the reference numerals utilized in FIGS. 1-3 with the exception that they are primed since the configuration is not exactly identical, but the operation and function are the same as that described for FIGS. 1-3. Shown in FIG. 4 is a solid piece of Plexiglas 17' having channels with a thickness of $\frac{5}{16}$ inch and a width of $2\frac{1}{2}$ inches. The $\frac{5}{16}$ inch channel is greater than the failure diameter of the liquid explosive utilized, which was a mixture of 95% nitromethane and 5% aniline. The explosive filled channels were initiated by a suitable means at the initiation point 31. The detonation traveled down the channel 21' up channel 24', and passed into channels 23' and 28. At this junction the detonation continued to travel the entire 2.5 inch length of channel 28, but failed to travel down the 2.5 inch long channel 23'. The detonation wave, traveling down channel 21', generated a shock wave which was transmitted and attenuated through the $\frac{1}{2}$ inch thick Plexiglas transmission medium 26', to pre-compress the detonable liquid in the channel 23'. As a result, detonation failed to propagate through the liquid in that channel. On the other hand the detonation proceeded through channel 28 because there was no collision between the detonation wave and a zone of precompressed liquid explosive, the detonation wave, in this region, always preceding the shock wave within the Plexiglas.

The dimensions for the apparatus of FIG. 4 are suitable for use of Plexiglas and nitromethane sensitized with 5% of aniline. For other liquid high explosives the dimensions would have to be altered to satisfy the parameters of the explosive and the transmission medium so as to obtain the proper level of pre-compression of the explosive. Since these parameters are known or are readily obtained by experiment, it would be a matter of straight forward engineering development for the particular system desired by utilizing the principles set forth in this present application.

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; for example applications to slurries and gels, such as thixotropic gels, are considered within the meaning of fluids as used above.

What is claimed is:

1. The method of quenching an explosion being propagated along a conduit containing fluid high explosive comprising the step of creating an explosion barrier by shock compressing a portion of said fluid high explosive, downstream of the detonation wave front, to a pressure region within which propagation of detonation is normally not maintainable, said pressure region being approximately midway between normal atmospheric pressure and the peak pressure of a shock required to produce a 50% probability of initiation of detonation of said fluid high explosive.

2. The method of quenching an explosion being propagated along a conduit containing fluid high explosive by creating an explosion barrier comprising the steps of

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generating a shock wave in response to a detonation in said high explosive fluid,
 propagating and attenuating said shock wave through a transmission medium,

intercepting the attenuated shock wave downstream of said detonation, and

compressing said explosive fluid, to a pressure region approximately midway between normal atmospheric pressure and the normal peak shock pressure required to produce a 50% probability of initiation of detonation of said explosive fluid, by the intercepted shock wave, to quench the detonation upon collision of the detonation with the pre-compressed explosive domain, which domain behaves as the explosion barrier.

3. A detonation arrester for use in a detonable fluid system

first fluid conducting means responsive to a detonation occurring within the explosive fluid contained therein, for transmitting a shock wave external to said fluid conducting means,

means in contact with said first conducting means for propagating and attenuating a shock wave transmitted by said first fluid conducting means,

and second fluid conducting means connected to said first fluid means and in contact with said means for propagating the shock wave, and responsive to the said shock wave for generating an explosion barrier by compressing the explosive fluid within said second fluid conducting means to a pressure region approximately midway between atmospheric pressure and the peak pressure of a shock wave required to initiate detonation 50% of the times, thereby to quench propagation and prevent detonation of the fluid beyond the explosion barrier.

4. A detonation arrester for use in a system containing a fluid high explosive comprising

a first substantially thin rectangular fluid conduit connected to the fluid system,

a second substantially thin rectangular fluid conduit superimposed and connected to said first conduit,

and a shock wave transmission medium positioned between said first and second fluid conduit,

whereby an explosion within the fluid system generates a shock wave in said first conduit which is transmitted by said transmission medium to said second conduit to compress the explosive fluid within said second conduit and to prevent propagation of detonation in the explosive fluid in the second conduit, thereby quenching the detonation.

5. A detonation arrester for use in a high explosive system comprising

a first shock transmitting channel containing a high explosive fluid and forming a part of the fluid system,

a shock receiving channel connected to the said first

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channel, to continue the fluid system, and lying adjacent to said first shock transmitting channel, and a shock transmission medium interposed and in contact with said first shock transmitting channel and said shock receiving channel,

whereby a detonation within said explosive fluid, upon arrival at said first shock transmitting channel, transmits a shock wave through said transmission medium to said shock receiving channel to pre-compress said explosive fluid therein to a pressure region approximately midway between atmospheric pressure and the peak pressure of a shock wave required for a 50% probability of initiation, thereby to create an explosion barrier within said shock receiving channel.

6. Apparatus as recited in claim 5 further comprising a second shock transmitting channel connected to said shock receiving channel to continue the fluid system and lying adjacent to said shock receiving channel, and a shock transmission medium interposed and in contact with said second shock transmitting channel and said shock receiving channel,

whereby a detonation arriving at said second shock transmitting channel creates an explosion barrier in said shock receiving channel after transmission and attenuation of the shock wave in said shock transmission medium.

7. Apparatus as recited in claim 6 further comprising a first container for said high explosive fluid connected to said first transmission channel, and a second container for said high explosive fluid connected to said second transmission channel.

8. Apparatus as recited in claim 7 wherein said first, and said second shock transmission channels and said shock receiving channel have a rectangular cross-sectional area and each of said channels lying in juxtaposition, but in a different parallel plane.

9. Apparatus as recited in claim 8 wherein said shock transmission medium completely embeds said first and said second shock transmission channels and said shock receiving channel.

10. Apparatus as recited in claim 9 wherein said high explosive fluid comprises nitromethane.

11. Apparatus as recited in claim 10 wherein said shock transmission medium comprises a linear thermoplastic methyl methacrylate polymer.

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SAMUEL W. ENGLE, *Examiner*.