Oct. 12, 1965 T. P. LIDDIARD, JR 3,211,094

EXPLOSIVE WAVE SHAPER

Filed May 18, 1960

FIG.1.

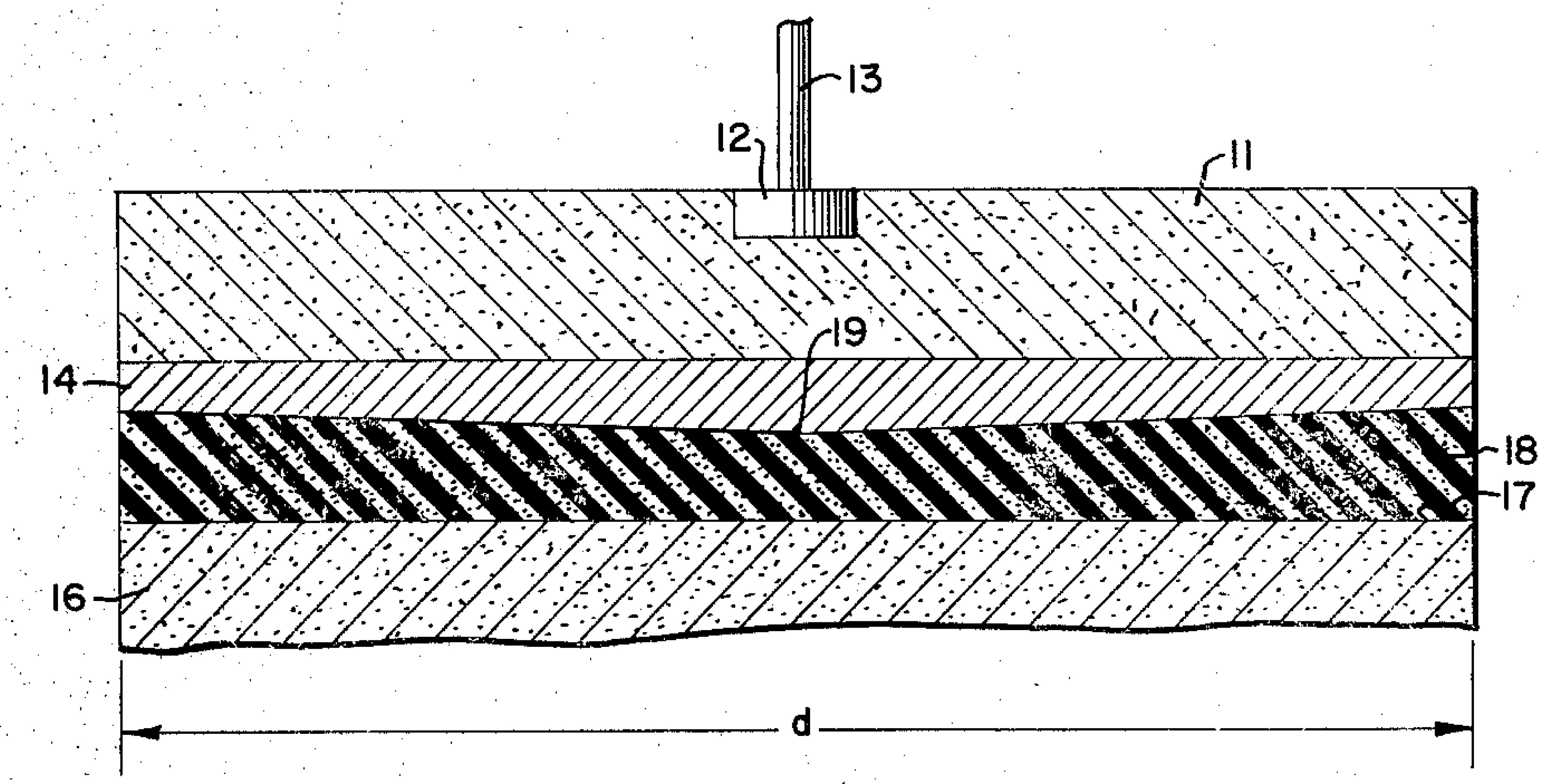
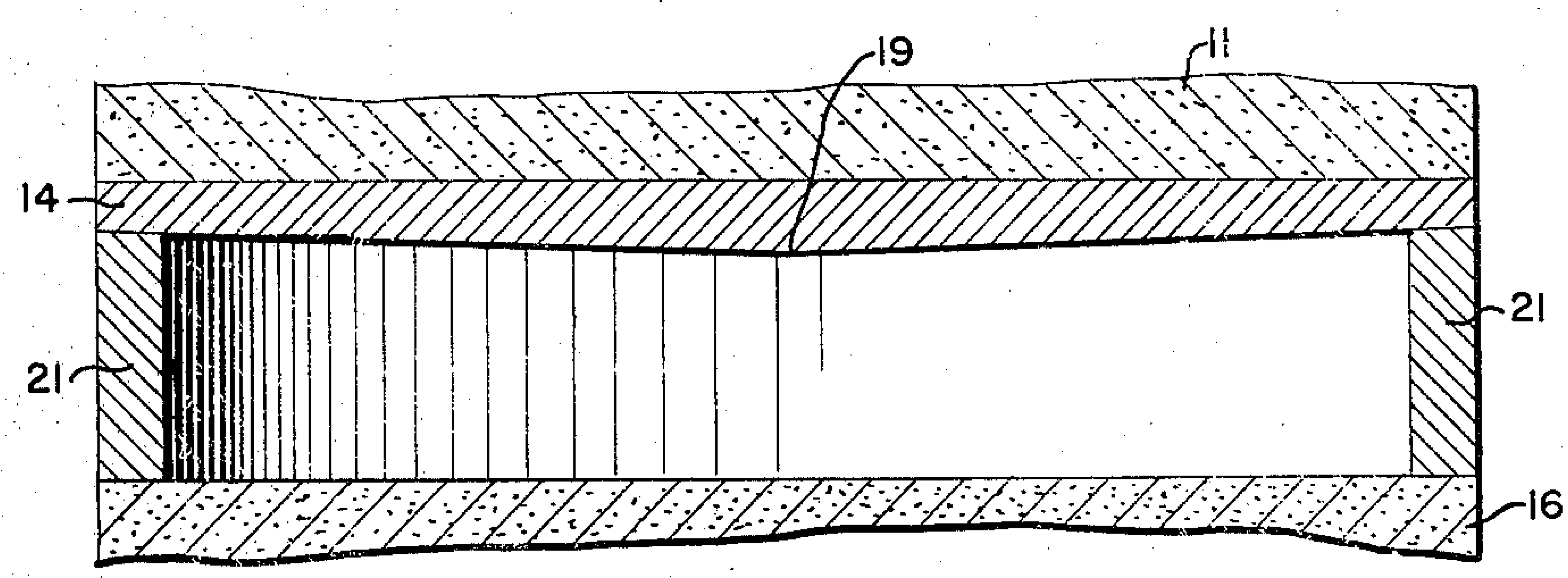


FIG.2.



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EXPLOSIVE WAVE SHAPER

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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.

This application relates to the explosives art and is more particularly concerned with a new and improved explosive wave shaping system or wave shaper.

It is known that many unique and desirable effects can be obtained in the detonation of an explosive by controlling the shape of the detonation wave in the explosive charge. The effects may be especially desirable in the field of ordnance. Accordingly, it is sometimes necessary to control the geometry of the detonation wave within rather narrow limits in order to obtain a desired explosive pattern or effect. For example, it is sometimes necessary that the explosive wave be planar. Since this is not possible when a conventional detonator is employed to directly detonate the working explosive, it has been found necessary to modify the explosive compact by employing a small amount of high explosive which is detonated in the usual manner. This explosive, called the donor explosive is employed to detonate the working explosive, the so-called acceptor explosive. By inserting an "air lens" between the two explosives it was possible to maintain a "planar" detonation wave across the main explosive. The air lens is a space between the donor and acceptor explosives so that the explosive wave which detonates the acceptor travels a sufficient distance from the initiator or donor explosive to produce flattening by geometric divergence. This air lens is too bulky for facile use in most ordnance or demolition applications.

Accordingly, it has been proposed to place a "flying" plate or disc of uniform thickness between the donor explosive and the acceptor explosive. The plate is driven against the acceptor explosive with sufficient force to detonate it. However, a precise depression must be pressed, cast, or machined into the acceptor in order to effect the properly shaped detonation wave front.

It is an object of this invention to provide a new and improved explosive wave shaper, that requires no complicated machining of the explosive components thereof.

Another object is the provision of a new and improved explosive wave shaper which is compact and includes a flying plate of non-uniform thickness.

These and many other objects will become more readily apparent when the following specification is read and considered along with the attendant drawings wherein:

FIG. 1 is a cross sectional view of a plane wave booster constructed according to the principles of this invention; and

FIG. 2 is a cross sectional view of a modified booster constructed according to the principles of this invention.

In practicing this invention, the shock transit time through, and the free flight time of an inert solid are utilized to modify the wave front of a detonation wave in a working explosive charge, the so-called acceptor explosive. This invention utilizes the fact that the free flight time of the inert solid is an inverse function of its thickness; the thicker the solid the greater is its free flight time. In effect, the variable thickness of the inert solid acts in a manner analogous to a variable index of refraction optical lens.

Referring now to FIG. 1, the booster includes a high explosive donor **11**, having a conventional initiator **12** such as tetryl embedded therein. A detonator **13** is affixed to initiator **12** and is connected in the conventional manner to a suitable voltage source (not shown) for initiation. Of course, the entire assembly may be encased in a suitable container or the like, as is the general practice. However, for simplicity, only the booster itself is shown.

Abutting donor explosive **11** is a solid inert, i.e., non explosive, body or transfer plate **14** which may be fabricated of steel. The plate may preferably have a flat planar face abutting the flat surface of explosive **11**. Although an irregular surface might be employed, it would necessitate pressing the donor explosive into it and is therefore slightly more complicated than the embodiment as shown in FIG. 1. The plate **14** is not of uniform thickness and as shown in FIG. 1, may be generally conical if it is desired to produce a planar detonation wave. Spaced from plate **14** is the acceptor or working explosive **16** which is detonated along its planar surface **17** by the flying plate.

A foamed plastic material **18** is interposed between plate **14** and the working explosive, and acts as a support and spacer without impeding the motion of the transfer plate **14**. Plastic **18**, being foamed has little crushing strength, and therefore transmits insufficient force from plate **14** to the acceptor explosive to detonate this explosive prior to impact by the plate.

As shown in FIG. 2, the plastic **18** can be eliminated by employing a ring **21** disposed about the periphery of transfer plate **14** and the acceptor explosive **16**. The ring need only have sufficient strength to give the proper spacing and support.

In operation, the device functions in the following manner: upon initiation of the detonator booster combination the explosive **11** is detonated at a rather small area rather than over a broad surface. The detonation waves progress radially outward from the detonation point at booster **12** so that the detonation wave front is curved and reaches the center **19** of the steel plate **14** prior to the time it arrives at the outer edges of the plate. Accordingly, the center portion of the plate first undergoes acceleration in the direction toward the working explosive **16**, and the outer portions begin acceleration at a later time. The local velocity of the metal plate varies inversely with the thickness thereof. Accordingly, by the judicious selection of thickness variation of the inert solid or transfer plate **14**, and the space between the plate and the acceptor explosive, it is possible to shape the detonation wave as it impinges upon the working explosive.

For example, a detonation wave which is plane to within 0.75 micro seconds (¼ inch) can be produced by making the thickness of plate **14** one eighth of an inch at the edges and tapering to a thickness of one quarter inch at the center, spaced one half inch from the acceptor explosive, and a donor explosive three quarters inch thick and having a tetryl booster embedded therein and having an overall diameter, *d*, of the assembly of six inches. When constructed in this manner, the surface of the flying plate at the moment it impacts the working explosive, is planar due to the local velocity variation thereof so that the detonation of the working explosive takes place at a plane.

Since the free flight time of the inert solid plate is a function of its local thickness, it acts in a manner analogous to an optical lens of a variable index of refraction. Obviously, therefore, the configuration of the wave shaper may be modified so that the geometry of the detonation wave as it initiates the working explosive may be altered to adapt the explosive charge to any desired purpose.

It should be apparent that this invention greatly facilitates the fabrication of the system since both high explosives, the donor and the acceptor may be flat slabs. The foam plastic 18 is not an essential feature of this invention. It serves only to support the assembly, and, having a high percentage of voids, to provide an air space between the acceptor explosive and the inert solid. This could also be accomplished by the use of a ring, sleeve, collar or the like such as that shown at 21. Collar 21 may be made of any suitable material, metal or plastic. The collar supports the plate 14 in position and at the same time provides the void space between the plate and high explosive 16.

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 as new and desired to be secured by Letters Patent of the United States is:

1. An explosive wave shaper comprising; a high explosive having a planar shock transmitting surface, means for detonating the high explosive at a point therein opposite the midpoint of said surface and at a predetermined distance therefrom, a solid deformable body in uniform contact with the surface of said explosive and adapted to be driven at high speed by the explosion thereof, said body having at least one thick portion at the central portion thereof and at least one thin portion surrounding the thick portion, the thick portion being driven at a slower speed than the speed of the thin portion upon explosion of said high explosive, and a second high explosive having a planar surface initially spaced from said body and positioned parallel to said first named surface whereby the second high explosive is impacted and detonated by said body when the body is deformed by the explosion of said first high explosive into matching relation with the planar surface of said second high explosive and driven into detonating relation therewith.

2. The wave shaper of claim 1 further including a foamed plastic element disposed between said solid body and said second high explosive for initially supporting said second explosive and said body in predetermined spaced relation.

3. The wave shaper of claim 1 further including a rigid annular sleeve engaging said solid body and said second high explosive at a peripheral portion and disposed therebetween for initially supporting said second explosive and said body in predetermined spaced relation, and said first-named high explosive is of sufficient strength to shear said body along the line of support of said annular sleeve.

4. An explosive wave shaping system comprising in combination; a donor explosive having a planar face extending thereacross through which a detonation wave therefrom is transmitted as the donor explosive is exploded and a second face parallel thereto, an acceptor explosive having a planar face extending thereacross and parallel to the planar face of the donor explosive through which

the detonation wave is received, means for detonating said donar explosive at a central recessed portion on said second face, said detonating means being located at a predetermined distance from the planar surface of the donor explosive, an inert deformable metallic plate having a flat surface in abutting relation to the planar face of said donor explosive, and means for yieldably supporting said plate with the flat surface thereof abutting the donor explosive and at a predetermined initial distance from the planar face of the acceptor explosive in excess of the maximum thickness of the plate, the surface of the plate opposite the flat surface thereof being conical and of sufficiently greater thickness at the central portion than at the periphery as to be deformed into matching relation with and driven against the flat surface of the acceptor explosive throughout the planar surface area thereof with sufficient force to detonate the acceptor explosive instantly by a planar shock wave applied thereto when the donor explosive is detonated.

5. The system of claim 4 in which the yieldable supporting means is composed of a foam plastic material having a high percentage of voids to provide an air space between the inert plate and the acceptor explosive.

6. The system of claim 4 in which the plate supporting means comprises a collar abutting the plate and acceptor explosive at the respective peripheral portions thereof.

7. A plane wave explosive detonating system comprising; a donor explosive having a single planar face through which a detonation wave therefrom is transmitted and a second planar face parallel thereto, means at a central portion of said second planar face for detonating said donor explosive, a deformable inert metallic momentum transfer plate having a flat surface and a conical surface disposed on opposite sides thereof, respectively, a working explosive having a single planar shock receiving surface opposite the apex portion of said plate, and means for initially maintaining said plate in a position such that the flat surface thereof abuts the single planar face of said donor explosive and said conical surface is disposed at a predetermined distance from said shock receiving surface of said working explosive whereby the plate is deformed and impacts the working explosive simultaneously throughout the receiving surface thereof upon the explosion of the donor explosive thereby to apply a planar shock wave thereto sufficient to explode the working explosive.

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