

Aug. 9, 1960

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CONTROLLED FRAGMENTATION OF IMPULSIVELY LOADED
BODIES BY STRESS WAVE INTERFERENCE

2,948,218

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2 Sheets-Sheet 1

Fig. 1.

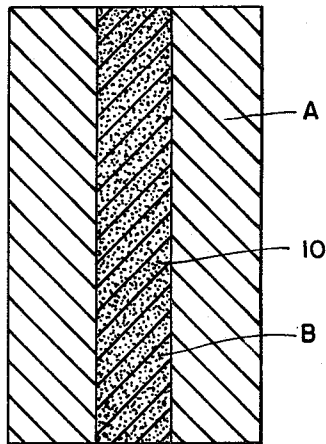
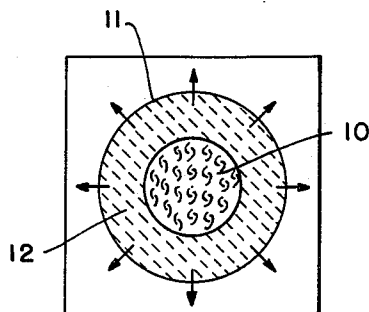


Fig. 2.

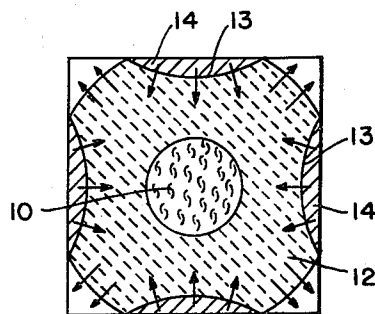


Fig. 3.

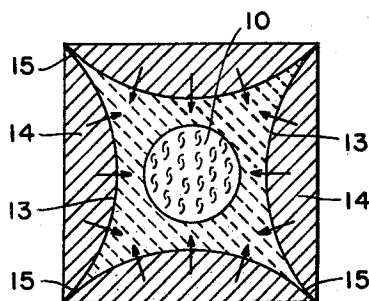


Fig. 4.

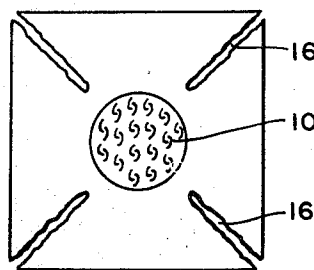


Fig. 5.

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2 Sheets-Sheet 2

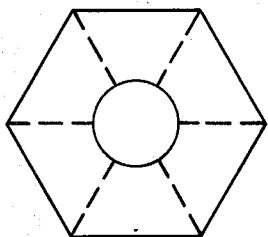


Fig. 6.

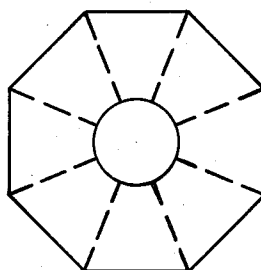


Fig. 7.

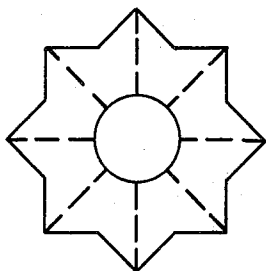


Fig. 8.

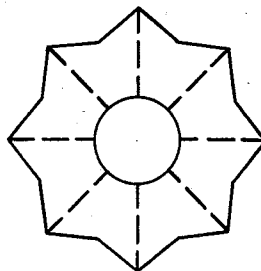


Fig. 9.

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2,948,218

CONTROLLED FRAGMENTATION OF IMPULSIVELY LOADED BODIES BY STRESS WAVE INTERFERENCE

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3 Claims. (Cl. 102—67)

(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.

This invention relates to fragmentation control methods and to articles constructed for controlled fragmentation in accordance with such methods. More particularly the invention relates to methods for designing and constructing comparatively thick-walled bodies which will have qualities of controlled and predictable fragmentation under explosive or other impulsive type loading, and to the bodies so designed and constructed.

Prior attempts at fragmentation control in impulsively loaded bodies, as for example, warheads, have involved the cutting of grooves or notches on such bodies in attempts to produce stress raisers and points of fracture initiation. Such methods have not been entirely satisfactory in that complete fragmentation control is not exercised and in that the formation of such grooves or notches involves added difficulty and expense in fabrication of such bodies. More recently it has been proposed to effect fragmentation control by shaping grooves in the explosive charge to provide localized shaped-charge effects upon detonation, and such methods have the disadvantage of requiring special charge shaping techniques and particular arrangements to effect satisfactory assembly of such charges with the warhead bodies. Such techniques have been particularly unsuitable where the casing wall is of a substantial thickness because the tensile stresses which cause fracture in such cases are less predictable than in comparatively thin-walled bodies which are known to fracture solely in shear.

Fracture may be caused in comparatively thick-walled impulsively loaded bodies by virtue of the interference of plural tensile stress waves resulting from reflections of various portions of the compression wave initiated by the impulsive load, from different free outer faces of such bodies to produce regions of tensile stress in excess of the critical normal fracture stress of the body material. We have discovered that the shape of the body predetermines the planes through the body along which such regions of tensile stress in excess of the critical normal fracture stress will occur, so that the fragmentation pattern can be predetermined by proper selection of body shape according to this invention. By virtue of our discovery and our method of applying it to fragmentation control problems it is possible to design and construct controlled fragmentation devices without resorting to the less accurate and more expensive methods of the prior art, since by varying the number of free outer faces and their orientation with respect to each other, the desired number and size of fragments can be obtained.

It is, therefore, an object of this invention to provide an improved fragmentation control method for comparatively thick-walled bodies wherein control is effected by the general external shape of the body as distinguished from the provision of grooves or notches thereon.

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It is a further object of this invention to provide thick-walled fragmentation devices having improved qualities of predictable and controlled fragmentation upon explosive or other impulsive loading.

5 A still further object of this invention is to provide improved fragmentation devices which are characterized in that the necessity for providing grooves or notches in the surface of the body to cause controlled fragmentation is obviated.

10 Another object of this invention is to provide fragmentation devices wherein improved control of fragmentation is effected by the external shape of the body of such devices.

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:

15 Fig. 1 is a vertical sectional view of a body in the form of a hollow square prism, showing such a prism filled with an explosive for causing an impulsive loading of the body;

20 Figs. 2 to 5 are schematic views of a section of the prism of Fig. 1, illustrating the progressive development of stress waves in said prism upon impulsive loading by detonation of the explosive, Fig. 5 showing the planes along which fragmentation finally occurs; and

25 Figs. 6 to 9 are schematic views of sections of variously shaped prismatic bodies, illustrating the principles of fragmentation control utilized in this invention and showing the predictable lines of fracture in each case.

Referring now to the drawings, there is shown in Fig. 1, a hollow square prism A having a centrally positioned bore 10, said bore being filled with an explosive charge B. The initiation of and progress of stress waves in the prism A will be completely described to illustrate the principles of this invention and their broad applicability to methods of predictable and reliable fragmentation control in bodies of other shapes.

40 Detonation of explosive B causes a shock wave to develop within the prism, starting at the bore 10. This shock wave initiates shear stress planes in the prism extending from the inner wall as far outwardly as the nature of the material and the degree of detonation will allow, but if the material of the casing is thick enough no fracture will result therefrom. However, the detonation also initiates a compression stress wave 11, which advances radially outwardly through the body, leaving behind it a region 12 of compression, as shown in Fig. 2. When compression wave 11 strikes the outer faces of the body, tensile stress waves 13 are propagated back into the compressed region 12, leaving behind stress relieved regions 14 which are in a state of reduced compression, as shown in Fig. 3. As tensile waves 13 advance inwardly through the body, they meet, as at 15 and form regions of tension along radial planes which pass through the corners of the prism, as shown in Fig. 4. If the magnitude of this resulting tensile stress is greater than the normal critical fracture stress of the body material, fragmentation of the body will occur along these planes 16, as shown in Fig. 5.

60 The above is illustrative of the physical principle upon which our invention is based. By virtue of our application of this principle it becomes possible to evolve a system or method of design of bodies of the class described to make possible predictable controlled fragmentation of such bodies under explosive or other impulsive loading, since the stress-wave phenomenon in many hollow polygonal prisms is similar to that discussed for the square prism of Figs. 1 to 5. Schematic showings of sections of several such shaped bodies are shown in Figs. 6 to 9, with their modes of fracture

indicated by the dotted lines. Figs. 8 and 9 differ from one another in that they have different depths between the points of the star-shaped cross-section, which illustrates how the thickness and weight of the resulting fragments may be varied. Variations from these shapes such as pentagonal or hexagonal cross-sections or star-shaped bodies with other than eight points, would result in correspondingly different numbers and sizes of fragments obtained, but entirely predictable, in each case. As the number of free outer faces is increased, more planes of tensile stress-wave interference are created within the body, and a correspondingly larger number of fragments will be formed. It is noteworthy that fracture always occurs at the thickest portions of the body walls rather than at the thinnest portion thereof, since the wall thickness is always great enough to resist fracture in shear at the thinnest portion and operable to be fractured by tensile stress waves at the thickest portion thereof.

The principles of the instant invention have wide application in the design of fragmentation devices of all types. They may obviously be applied to many variations in the shape of such devices, as already indicated, and are obviously applicable to metal-explosive systems other than internally loaded prisms. Moreover, numerous other possibilities exist in utilizing the described theory. For example, although the specific illustrations described in this application relate only to controlling the longitudinal fragmentation of prismatic bodies, the same principles can be used to control fragmentation in planes angularly disposed to the longitudinal axis as well. This can be done by orienting the outer faces of the bodies so that the reflected tensile waves cause both longitudinal and horizontal planes of interference. It is also obvious that, by the stacking of a number of flat pieces, each piece having the required prismatic shape, a fragmentation pattern involving both longitudinal and horizontal dispersion of particles will result.

From the above it should be obvious that we have invented a new and improved fragmentation control method resulting in fragmentation devices having superior qualities of controlled fragmentation and that we have evolved a new method for the design and construction of fragmentation devices which is based upon an improved theory of fragmentation prediction and control.

Obviously, many modifications and variations of the invention are possible in the light of the above teachings. It is therefore to be understood that the scope of the invention is to be considered as limited only by the scope and limitations of the appended claims.

What is claimed is:

1. A fragmentation device comprising a solid body having at least a portion thereof in the form of a polyhedron, said polyhedron having regular polygonal ends having equal numbers of sides and planar lateral face surfaces in the form of quadrilaterals, said body having a central cylindrical chamber containing means to impulsively load the body to initiate a compression stress wave in the body, the thickest wall portions of said body operable to be fractured by tensile stress waves caused by said impulsive loading means, the thinnest wall of said body being of a thickness to prevent fracture in shear from said impulsive loading means.

2. A fragmentation device according to claim 1, in which said portion of said body is a prism having a cross-section in the shape of a regular polygon, the number of fragments resulting therefrom upon impulsive loading equalling the number of sides of said polygon.

3. A fragmentation device comprising a solid body having at least a portion of the outside thereof in the form of a prism, said prism having a central longitudinal chamber and walls of a thickness such as to prevent fracture in shear from a given impulsive loading, said chamber containing means to impress said given impulsive loading upon said body to initiate a compression wave in said body which will impinge on the outer surfaces of said prism and be reflected as tensile stress waves, whereby fragmentation of the body is effected by interference of said tensile stress waves along planes extending from said chamber through the lines of intersection of the lateral faces of said prism with one another.

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