Feb. 23, 1965 H. S. MORTON ETAL 3,170,402

EQUAL LENGTH DETONATING CORDS FOR WARHEAD DETONATION

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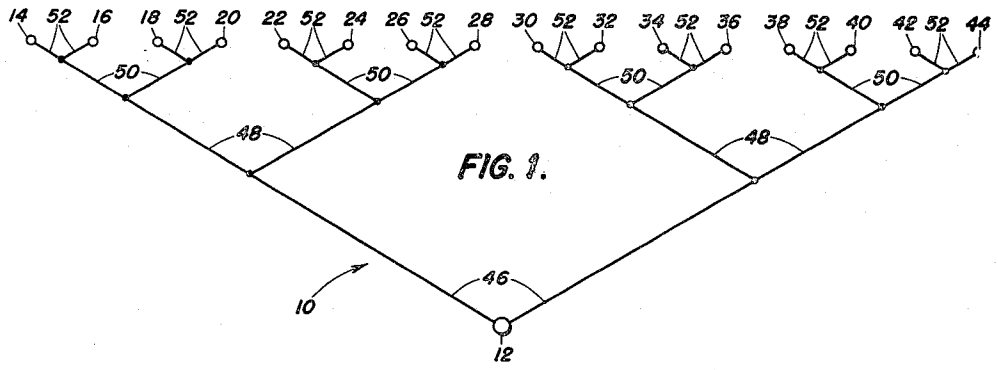


FIG. 1.

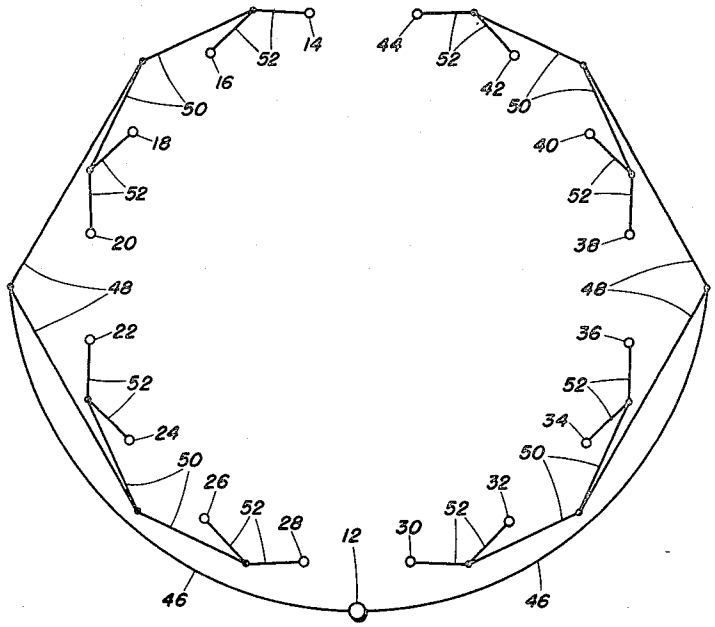


FIG. 2.

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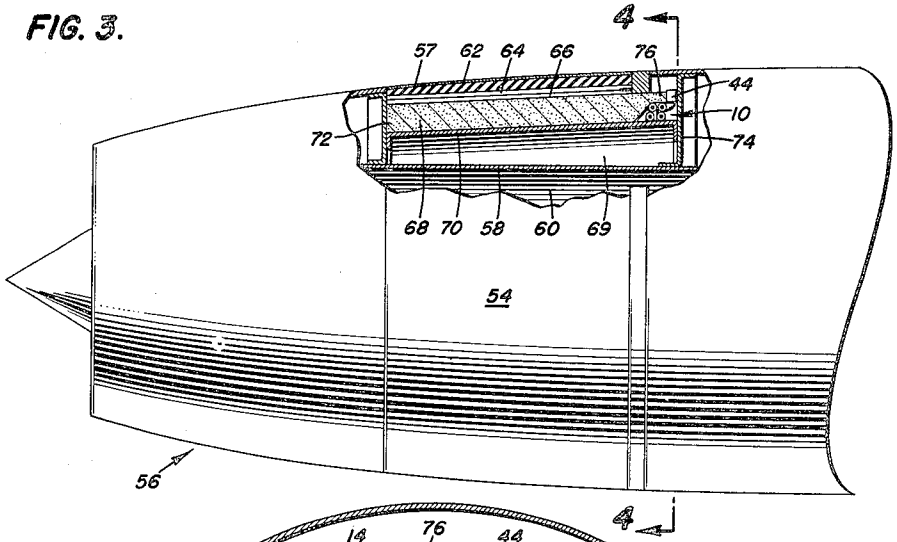
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FIG. 3.



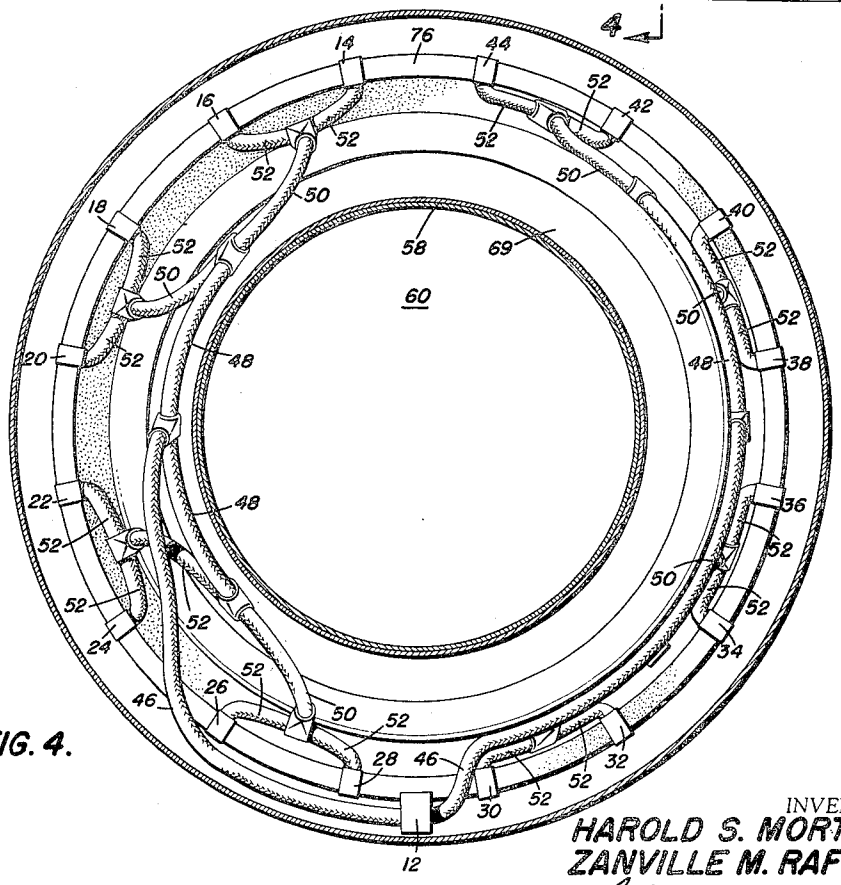


FIG. 4.

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EQUAL LENGTH DETONATING CORDS FOR WARHEAD DETONATION

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2 Claims. (Cl. 102—70)

This invention relates generally to explosives, and more particularly to a method and a system for exploding annularly arranged explosive charges.

Some types of present day aerial missiles are provided with continuous-rod warheads. These warheads are described in the U.S. patent application of Eugene L. Nooker for Continuous Rod Warhead, Serial No. 590,078, filed June 7, 1956, and consist essentially of a cylindrical explosive charge having a layer or layers of connected rods lying thereabout and parallel to its longitudinal axis. The charge of explosive is, in many instances, annular in form.

In order to obtain the maximum effect from an annular warhead, it is necessary to initiate a detonation of the explosive charge in such a way that the layer or layers of rods lying outside the cylindrical annulus and parallel to its longitudinal axis are expelled laterally with a minimum tendency to break apart or form an unsymmetrical pattern.

Initiation of the explosive charge at a single point, as in ordinary shells, bombs, and warheads is possible but does not produce optimum results, because the unsymmetrical propagation of the detonation wave along and around the warhead causes the undesired breakage of the rods and the consequent non-uniformity of the pattern of the fragments.

In order to have an ideal initiation of the explosive charge, it is necessary to produce a plane detonation wave which moves along the charge in an axial direction, with its front in a plane perpendicular to the longitudinal axis of the explosive annulus.

If there were no limitation as to the length and weight of the explosive charge extending beyond the end of the rod assemblies, and if there were no restriction against using the space lying inside the annular explosive charge (or an axial extension thereof), it would be possible to propagate a detonation wave from a single point of initiation which would approach an ideal wave form by the time it reached the rods in the warhead. Unfortunately, only a few inches of extra length can be spared in an aerial missile for initiation devices and for the generation of a smooth detonation wave in the missile. No encroachment whatsoever is permissible into the center of the explosive annulus.

If approximately simultaneous detonation of the explosive can be achieved at all points along the circumference of the explosive annulus at one end thereof, the desired wave form will be produced. However, means for approximating such an initiation of the explosive annulus electrically involves equipment having volume and weight greater than currently available.

A method has been developed, therefore, for obtaining approximately simultaneous initiation of an annular explosive charge at a multiplicity of points equally spaced along the periphery of the explosive annulus at one end thereof and a few inches from the ends of the rods in the warhead in order that the waves emanating from this multiplicity of points may have a chance to coalesce into a reasonably smooth wave front around the entire explosive annulus by the time they reach the rods. A proper selection of total number of initiation points for the explosive charge located a suitable distance from the ends

of the rods has been shown by tests to give satisfactory results.

It is one of the objects of this invention, therefore, to provide a method as well as a system for achieving approximately simultaneous detonation at all points along the circumference of an explosive annulus at one end thereof.

Still another object of this invention is to provide a method and a system for obtaining ideal detonation of an explosive annulus in such a way that the layer or layers of rods lying outside of the annulus and parallel to its longitudinal axis are expelled laterally with a minimum tendency to break apart or to form an unsymmetrical pattern.

And still another object of this invention is to provide a unique arrangement of an initiation system for exploding an annularly arranged explosive charge.

To provide an initiation system, for exploding an annularly arranged explosive charge, which is easy to install in a missile within a limited space and which is efficient and reliable in operation, are still other objects of this invention.

These and other objects and advantages of this invention will become more apparent from the following specification and drawings, in which:

FIG. 1 is a schematic illustrating one arrangement of a detonating cord system constituting this invention;

FIG. 2 is a schematic of the detonating cord system shown in FIG. 1, with points of initiation circularly arranged;

FIG. 3 is a side view of a portion of a missile, partly in elevation, illustrating a rod-type warhead incorporating the detonating cord system of FIGS. 1 and 2; and

FIG. 4 is a cross-section along line 4—4 of FIG. 3.

In accordance with the invention, a method and system is provided for producing approximately simultaneous initiation of an explosive annulus at a multiplicity of points equally spaced along the periphery of the annulus and at one end thereof. The method and system consists of providing "equal length" paths of shielded detonating cord from a single point of initiation of the system, with the ends of the detonating cord paths being provided with a multiplicity of points for initiation of the explosive annulus. A detonating cord is defined as a flexible (either fabric or metal) tube containing a filler of high explosive which can be set off by a blasting cap or by an electrical detonator. A detonating cord is commonly known as a "Prima-cord."

The detonating cord is placed in an annular sheet network adjacent to the end of the explosive annulus, and a suitable igniting means is then provided at each end of the detonating cord paths of the shielded cord to ignite the explosive annulus. The detonating cord is then ignited at the single point of initiation so that the waves emanating from the multiplicity of path ends coalesce into a smooth wave front adjacent the end of the explosive annulus. The smooth wave front moves axially along the explosive annulus to detonate the annulus uniformly at a multiplicity of points equally spaced along the periphery thereof.

In recent studies of rod-type warheads, initiation of the hollow cylindrical explosive charge has been obtained by extending the explosive annulus a considerable distance beyond the end of the rods, and cenrally initiating a sheet of explosive placed across the open end. This method produces a plane detonation wave front moving axially along the hollow cylindrical charge. In the actual missile, the extra length of the explosive is limited and it is impossible to encroach on the central opening. It has become necessary, therefore, to devise a method for generating an approximately straight wave front within a few

inches of the end of the annular charge by the simplest practical methods.

Detonating cord propagates detonations at high velocity (comparable to detonation velocities in high explosive charges), with negligible probability of failure or interruption and small variations in velocity within a given lot. Standard detonating cord can be effectually "contained" so that it will not detonate an explosive in contact with its casing.

Multiple points of initiation of an explosive annulus can be detonated simultaneously by providing "equal-length" paths of detonating cord from a single initiation. Properly shielded detonating cord is nested in an annular network adjacent to the end of the explosive annulus without damaging it or detonating it. Sixteen (16) points of initiation may be reached by equal lengths of cord with no more than four (4) cords abreast at any point around the circumference.

Referring now to FIG. 1 of the drawings, there is illustrated a schematic of the detonating cord system 10 constituting this invention. The system 10 consists of a single initiation point 12, with sixteen equally spaced points of initiation 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42 and 44. Each point 14, 16, 18 etc., is connected to the single point of initiation 12, by pairs of equal length detonating cords 46, 48, 50 and 52.

The method of carrying detonations from a single source, such as point 12, to a multiplicity of end points 14, 16, 18, etc., consists in the use of the previously mentioned detonating cord. Detonating cord consists of a core of explosive material encased in a flexible non-explosive casing (resembling very much a flexible stranded copper wire encased in insulation). Detonations propagate along the detonating cord at velocities of several thousand feet per second, and the velocity may be kept very uniform by carefully controlled production techniques. When two or more unshielded detonating cords are bound closely side-by-side, the detonation jumps from one to the other, so that is possible to start with a single cord and then divide and sub-divide, as shown by detonating cord system 10, in FIG. 1, until detonations are traveling along a number of cords simultaneously.

If all of the cords are cut so as to provide equal length paths from the source 12, the detonations will arrive at the points 14, 16, 18, etc., at approximately the same time. By use of suitable caps on the ends of the several cords, and boosters which are initiated by these caps, the main explosive charge may be initiated at numerous different points.

Standard detonating cords (unarmored and unprotected) propagate from one to another if they make contact where they cross one another, but they are usually knotted together, wrapped one around the other or bound together, lying parallel for short lengths, to assure propagation from one to the other.

Normal contact between the free end of standard detonating cord and some kinds of explosives (such as tetryl) is all that is required to initiate detonation of the latter. A variety of "boosters" are available consisting of a light metal case with a tubular opening the size of the detonating cord, which can be slipped onto the free end of the cord and crimped in place with a convenient hand tool resembling a pair of pliers. These cases contain a small amount of explosive sensitive enough to be detonated by the detonating cord which will then detonate larger charges of less sensitive explosive.

In FIG. 2, there is illustrated a schematic of the detonating cord system 10, but with the points of initiation 14, 16, 18, etc., arranged circularly as would be used in connection with a warhead 54, as shown in FIGS. 3 and 4.

The warhead 54 is shown mounted in an aerial missile 56 of the ramjet type, although other types of missiles can be arranged to utilize this type of warhead. The missile 56 has an outer skin 57 and an inner skin 58 defining a duct 60. Duct 60 extends throughout the length of missile 56, and is used for receiving air which is to be compressed in a diffuser (not shown) and mixed with fuel. The air-fuel mixture is subsequently burned in a combustion chamber located in the downstream end of the duct 60. The combustion gases liberated by burning of the mixture pass through an exit nozzle located at the rear of the missile to develop thrust for propelling the missile 56.

As seen best in FIG. 3, an annulus 62 of foam plastic material surrounds the warhead 54. This annulus 62 of plastic material is located adjacent to the outer skin 57 of the missile 56. The warhead consists of at least one layer but preferably two layers 64 and 66 of one-quarter inch square metal rods, located adjacent the annulus of foam plastic material 62, and an explosive annulus 68 of two to two and one-half inches in thickness located between the layers of rods 64 and 66 and the missile axis. The layers of rods 64 and 66, and the annulus 62 of plastic material extend between annular channel members 72 and 74.

An annular chamber 69 is located between the explosive annulus 68 and the inner skin 58 of the missile 56. The chamber 69 is separated from the explosive annulus 68 by a channel member 70. Channel members 72 and 74, of annular shape, close the ends of chamber 69 and abut the ends of the explosive annulus 68.

The explosive annulus 68, at one end 76, is made longer than the layers 64 and 66 of rods, and it is of reduced thickness, as shown, to receive the detonating cord system 10, as previously described in connection with FIGS. 1 and 2 and illustrated diagrammatically in FIG. 4.

As best seen in FIG. 4, suitable means included a tetryl booster is located at point 12 to ignite the detonating cord system 10, and similar booster elements will be located at the terminal ends of the detonating cord system at initiation points 14, 16, 18, etc. These booster elements are positioned in or adjacent to the surface of the extended end 76 of the explosive annulus 68, and they are utilized to set off the explosive annulus.

In order to determine how far along the explosive annulus 68 the wave resulting from multiple points of initiation, spaced at a distance d apart, will have to move before it assumes a flat wave front, so that it will not cause rod breakage because of uneveness in the pressures generated by the explosive, the test discussed below can be utilized.

A slab of explosive is prepared and is initiated at several points a distance d apart. The "length" of the slab is Kd, where K is an unknown factor to be determined. The technique of U-shaped lengths of detonating cord laid on a sheet of metal (lead, dural, tin, etc.) is used to "scan" the shape of the wave front at the distance Kd from the end on which the initiations take place. The point of meeting on the U is marked on the metal sheet, and it will show the relative positions of different points on the wave front.

The factor K is varied until the minimum length is found in which a reasonably smooth wave front can be obtained. If this length is more than it should be for the spacing given by 16 initiation points, as previously described, it may be necessary to try to obtain 32 points of initiation. The final sub-division of 16 points into two each need not necessarily be shielded on all sides, but only from the explosive immediately adjacent thereto.

In actual operation, the detonating cord system 10 can be ignited by an electrical signal from a radio proximity fuze (not shown) or the like. The detonating cord in the various sections 46, 48, 50 and 52 burns at a uniform rate to set off the boosters at the points 14, 16, 18, etc. to ignite the explosive annulus 68 at a multiplicity of points along its extended peripheral end 76. The waves emanating from the multiplicity of points coalesce into a reasonably smooth wave front around the entire explosive annulus 68 by the time they reach the layers of rods 62 and 64, with the result that the rods are expelled in a uniform pattern from the missile 56.

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 detonating cord initiating system for detonating an explosive annulus, comprising, an initial detonator, a first plurality of equal lengths of armored detonating cord emanating from said initial detonator, a first junction fitting terminating each of said first plurality of equal length cords, a second plurality of equal lengths of armored detonating cord emanating from each of said first junction fittings, a second junction fitting terminating each of said second plurality of equal length cords, a third plurality of equal lengths of armored detonating cord emanating from each of said second junction fittings, and explosive means terminating each of said third plurality of equal length cords for initiating said explosive annulus, said explosive means being positioned at equally spaced points on the periphery of said annulus, whereby ignition of said initial detonator will cause the resultant detonation waves to travel along equal length paths to the equally spaced points on said annulus to produce uniform detonation of said annulus.

2. A detonating cord initiation system for detonating an explosive annulus, comprising, a single point of initiation; a dendritic network of armored detonating cord, said network having a first plurality of equal lengths of armored detonating cord emanating from said point of initiation, a second plurality of equal lengths of armored detonating cord, said second plurality being divisible into groups equal in number to the number of equal length cords constituting said first plurality and having each length within each group depending from a common junction at the end of each length included in said first plurality, and successive pluralities of equal lengths of armored detonating cord, each of said successive pluralities being divisible into groups each of which depends from the end of a cord included in the preceding plurality, the ends of each cord in the final plurality being positioned at points equally spaced around the periphery of said annulus; and means for igniting said point of initiation, whereby the resulting detonation waves are caused to travel along equal half-lengths of armored detonating cord to produce uniform detonation of said explosive annulus.

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