Jan. 20, 1970 A. A. LAVINE 3,490,372

PROJECTILE ACCELERATION ARRANGEMENT

Filed Nov. 9, 1966

3 Sheets-Sheet 1

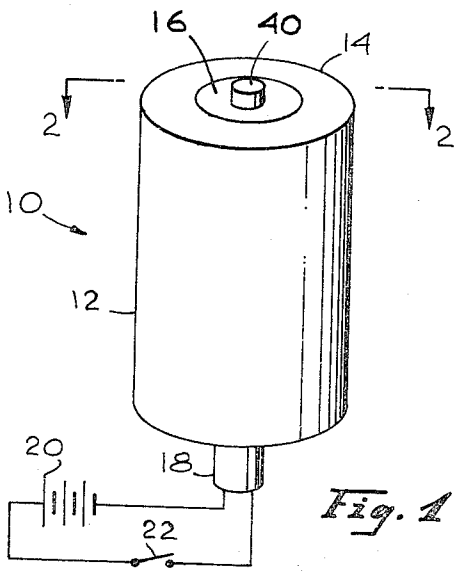


Fig. 1

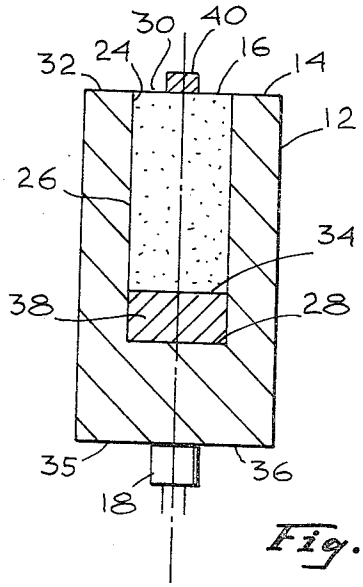


Fig. 2

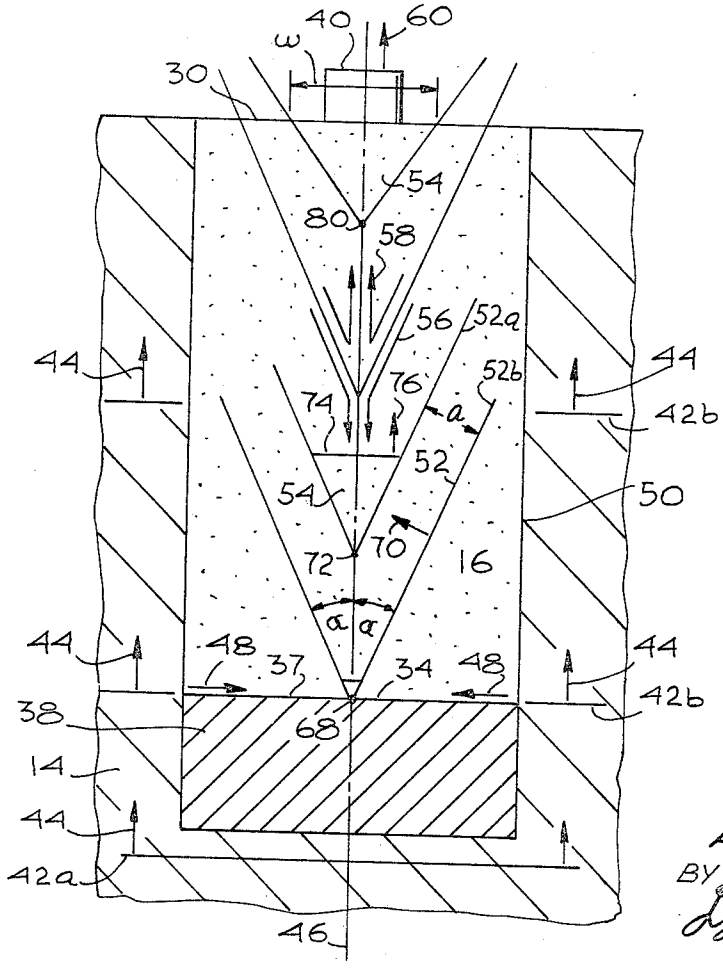


Fig. 3

INVENTOR
ARTHUR A. LAVINE
BY
Don Finkelstein
ATTORNEY

Jan. 20, 1970 A. A. LAVINE 3,490,372

PROJECTILE ACCELERATION ARRANGEMENT

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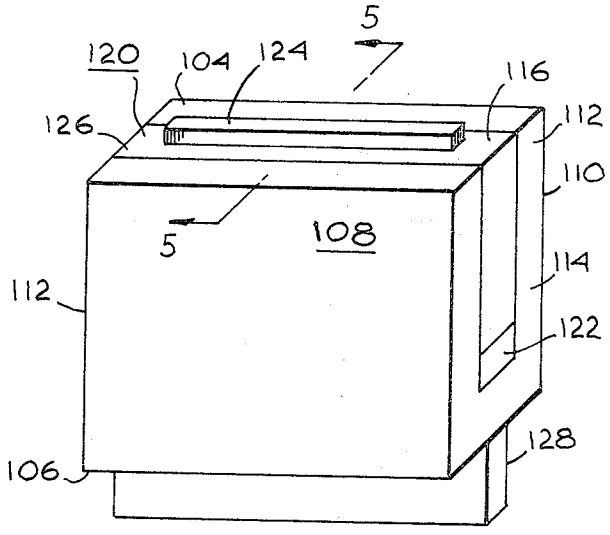


Fig. 4

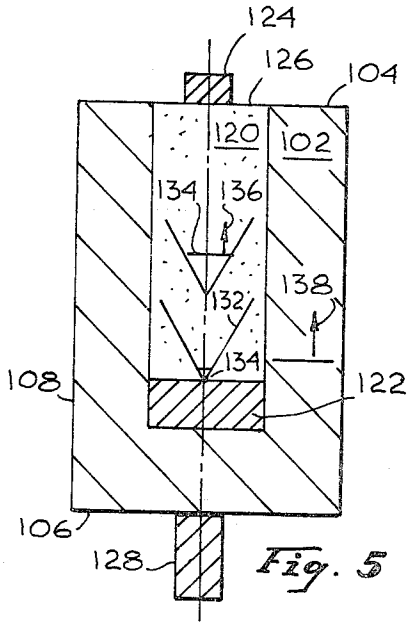


Fig. 5

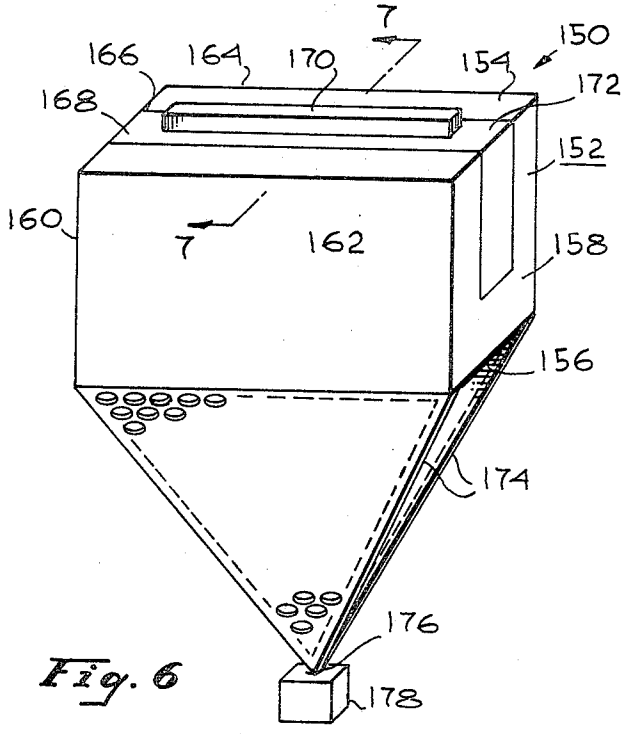


Fig. 6

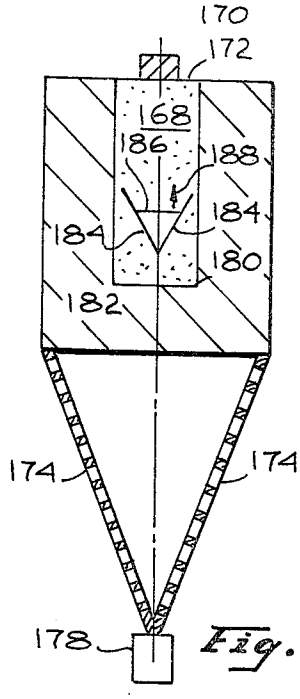


Fig. 7

INVENTOR
ARTHUR A. LAVINE
BY
Don Feinbelstein
ATTORNEY

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PROJECTILE ACCELERATION ARRANGEMENT

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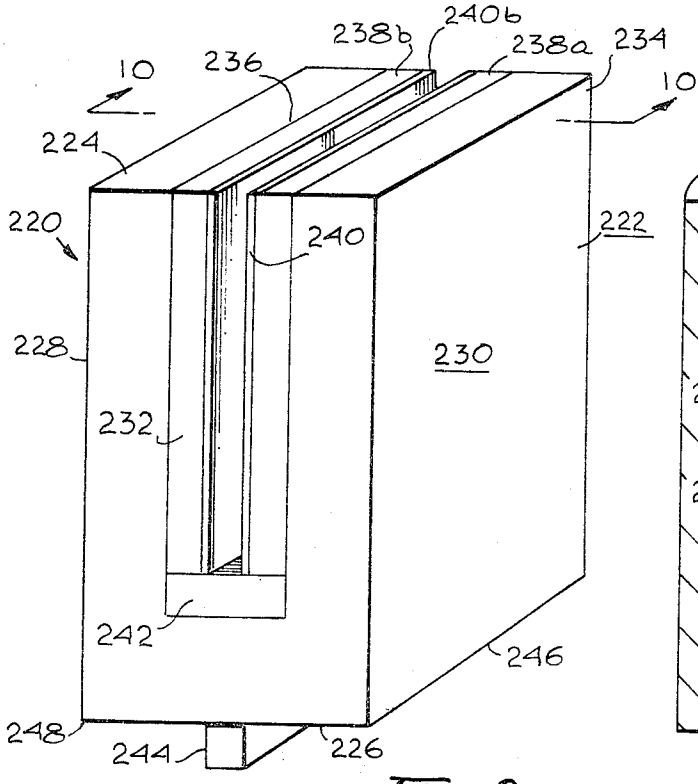


Fig. 9

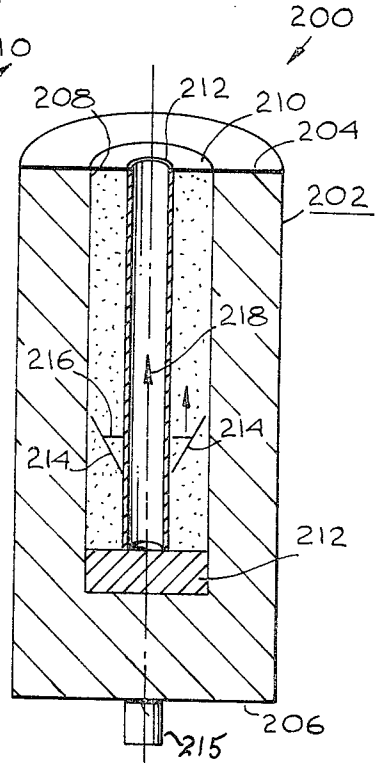


Fig. 8

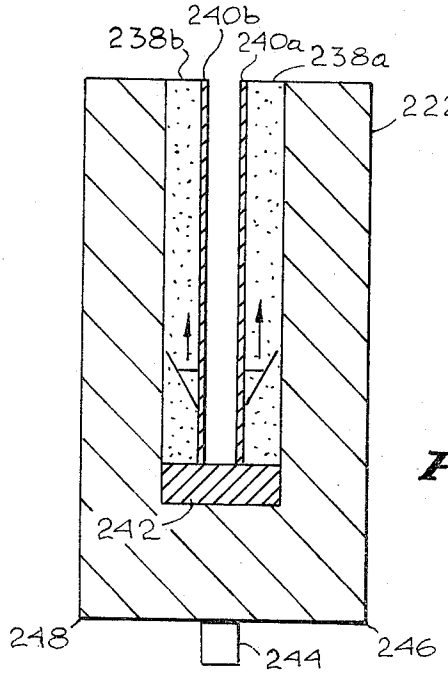


Fig. 10

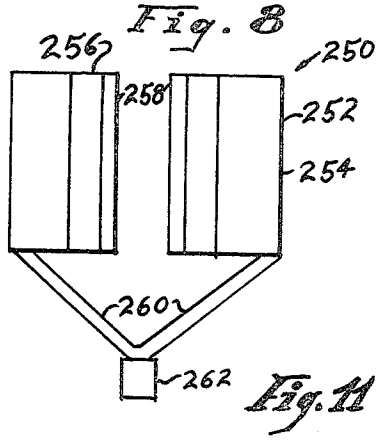


Fig. 11

INVENTOR
ARTHUR A. LAVINE
BY
Don Finkelstein
ATTORNEY

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PROJECTILE ACCELERATION ARRANGEMENT

Arthur A. Lavine, 5322 Waupaca Road,
Palos Verdes Peninsula, Calif. 90274

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Int. Cl. F42b 1/02, 9/14
U.S. Cl. 102—24 9 Claims

ABSTRACT OF THE DISCLOSURE

There is described in this patent application an explosive configuration in which a first high explosive charge member and a second high explosive charge member are combined to provide a constant angle Mach stem for the acceleration of a projectile or generation of a shaped charge. The first high explosive charge member has a detonation front velocity that is always greater than the detonation front velocity in the second high explosive charge member. The constant angle Mach stem generated in the second high explosive charge member provides a constantly increasing momentum for acceleration of a projectile or generation of a jet in a shaped charge.

This invention relates to the projectile art and more particularly to an improved means for accelerating a projectile to a very high velocity.

In many applications it is often desirable to accelerate a projectile, or other structure, to a very high velocity. Such applications, of course, include projectiles accelerated by high explosives as may be found in conventional ammunition, hypervelocity particle study, and heat generation studies obtained from the impact of high velocity projectiles. It will be appreciated that applicant uses the word "projectile" to encompass all forms of structure that may be accelerated by the techniques described herein and is not to be construed as limiting to any type or class of such structure.

While various techniques utilizing high explosives for providing high projectile velocities have heretofore been proposed, the maximum velocities actually achieved in such prior art arrangements have been on the order of 10,000 feet per second. Such arrangements have often utilized a high explosive in which there is generated a variable angle (Mach stem) as disclosed, for example, in The Science of High Explosives, by Melvin A. Cook, 1958, Reinhold Publishing Corporation, New York, N.Y. However, a variable angle Mach stem utilized in these high explosive techniques has not been able to provide the ultra-high projectile velocities in the above-mentioned applications wherein it is often desired to have projectile velocities on the order of 40,000 or more feet per second.

Accordingly, it is an object of applicant's invention herein to provide an improved structure for accelerating projectiles.

It is another object of applicant's invention herein to provide a high explosive charge arrangement in which a constant angle Mach stem is generated.

It is yet another object of applicant's invention herein to provide a high explosive charge arrangement in which a constant angle Mach stem is generated for accelerating a projectile to a very high velocity.

The above and other objects are achieved, according to one embodiment of applicant's invention, by providing a substantially cylindrical first high explosive charge member having a cylindrical aperture extending from one end thereof a predetermined distance axially inwardly toward the second end thereof. The aperture has a base portion that is spaced apart from the second end of the first high explosive charge member. A second cylindrical high explosive charge member is positioned within the aperture and the first end of the second cylindrical high explosive charge member is substantially coplanar with the first end of the first cylindrical high explosive charge member and the second end of the second cylindrical high explosive charge member is spaced from the base portion of the aperture.

An inert cylindrical member is positioned in the aperture intermediate the second end of the second cylindrical high explosive charge member and the base portion of the aperture. The inert cylindrical member is a wave shaper to shape a detonation front generated by the ignition or detonation of the high explosive charge members.

In this embodiment the exterior surface of the second end of the first cylindrical high explosive charge member is the preselected surface portion for ignition thereof to initiate the generation of a detonation front. The detonation front moves axially along the first cylindrical high explosive charge member and is intercepted by the above-mentioned wave shaper. The detonation front velocity in the first cylindrical high explosive charge member is a first predetermined value and the detonation front velocity in the second cylindrical high explosive charge member is a second predetermined value less than the first value.

Therefore, as the detonation front passes the wave shaper it generates a detonation front in the second cylindrical high explosive charge member. However, since the detonation front velocity of the second cylindrical high explosive charge member is less than the detonation front velocity in the first cylindrical high explosive charge member, the detonation front converges toward a point along the axis of the second cylindrical high explosive charge member at a predetermined angle, and, according to the principles of applicant's invention, this angle is preferably maintained comparatively small and is constant. This substantially constant, small angle generated by the detonation front in the second cylindrical high explosive charge member generates a Mach stem of increasing momentum comprised of comparatively high density gases. In this embodiment of applicant's invention, the Mach stem is substantially conical in shape because of the symmetrical nature of the second cylindrical high explosive charge member about its axis.

As the Mach stem traverses the second cylindrical high explosive charge member, the momentum thereof substantially increases continually until it reaches the first end thereof.

A projectile which is to be accelerated is positioned on the first end of the second cylindrical high explosive charge member and the effect of the high momentum Mach stem on the projectile accelerates the projectile to comparatively high velocities.

In other embodiments of applicant's invention there is provided a high explosive charge means in which a substantially wedge-shaped Mach stem is generated to provide an arrangement for accelerating an elongated projectile.

The above and other objects are understood more completely from the following detailed description taken together with the accompanying drawing wherein similar reference characters refer to similar elements throughout and in which:

FIGURES 1, 2 and 3 illustrate one embodiment of applincant's invention and the principles of operation thereof;

FIGURES 4 and 5 illustrate another embodiment of applicant's invention;

FIGURES 6 and 7 illustrate another embodiment of applicant's invention;

FIGURE 8 illustrates another embodiment of applicant's invention;

FIGURES 9 and 10 illustrate another embodiment of applicant's invention; and

FIGURE 11 illustrates a directed sheet warhead embodiment of applicant's invention.

It will be appreciated that while applicant has chosen some specific embodiments of his invention for illustration of the techniques for providing high projectile velocities, such embodiments as illustrated and described herein are not to be construed as limitations upon the broad concepts of applicant's invention. Further, where practical, the structure and design features illustrated in one embodiment may be equally well used in other embodiments to provide the improvements in high projectile velocity structures according to applicant's invention.

Referring now to FIGURES 1, 2 and 3, there is shown the structure associated with one embodiment of applicant's invention. As shown in FIGURE 1, there is a projectile accelerator, generally designated **10**, comprised of a charge means **12** that, in this embodiment of applicant's invention, is cylindrical.

The charge means **12** is comprised of a first cylindrical high explosive charge member **14** and a second cylindrical high explosive charge member **16**. An initiator or detonator means **18** which, for example, may be electrically ignited through source of electrical energy such as battery **20** and switch means **22**, is utilized to ignite or detonate the charge means **12**.

The first cylindrical high explosive charge member **14** has walls **24** defining an aperture **26** which has a base portion **28**. As shown in FIGURES 1, 2 and 3, the second cylindrical high explosive charge member **16** is positioned in the aperture **26** and has a first end **30** that is substantially coplanar with the first end **32** of the first cylindrical high explosive charge member **12** and a second end **34** that is spaced apart from the base portion **28** of the aperture **26** and from the second end **36** of the first cylindrical high explosive charge member **14**.

The detonator **18** is coupled or otherwise affixed to the exterior surface **35** of the second end **36** to provide ignition or detonation of the high explosive charge means **12** to commence the generation of a detonation front therefrom.

An inert cylindrical member **38** is positioned intermediate the second cylindrical high explosive charge member **16** and the base surface **28** of the aperture **26** and is a wave shaper to provide the proper shaping of the detonation front wave as it traverses through the charge means **12**.

A projectile **40** is coupled or otherwise affixed to the second end **30** of the second cylindrical high explosive charge member **16** and, for this embodiment of applicant's invention, the projectile **40**, the first cylindrical high explosive charge member **14** and the second cylindrical high explosive charge member **16** and the detonator **18** are substantially coaxially aligned.

When it is desired to accelerate the projectile **40**, according to applicant's invention herein, the detonator or initiator **18** is energized and this commences the generation of a detonation front from the second end **36** of the second cylindrical high explosive charge member **14**.

This phenomena is more clearly illustrated in FIGURE 3. As shown in FIGURE 3, the detonation front indicated by the line **42***a* is traversing the first cylindrical high explosive charge member **14** in the direction indicated by the arrow **44**. As the detonation front **42***a* is intercepted by the wave shaper inert cylinder **38**, it commences to travel through the annular section of the first cylindrical high explosive charge member **14**, which surrounds the aperture **26**. As the detonation front approaches and impinges upon the peripheral edge **37** of the bottom surface **34** of the second cylindrical high explosive charge member, the detonation front is generated in the second cylindrical high explosive charge member **16**.

The first cylindrical high explosive charge member is selected to have a detonation front velocity that is greater than the velocity of the detonation front in the second cylindrical high explosive charge member **16**. As such, a generally conical detonation front is provided in the second cylindrical high explosive charge member **16** that has its apex along the axis **46** as the detonation front moves radially inwardly as indicated by the arrow **48** in the second cylindrical high explosive charge member **16** and the detonation front **42** moves in the direction indicated by the arrow **44** along the side peripheral wall **50** of the second cylindrical explosive charge **16**.

Thus, the detonation front **52** moving in the second high explosive charge member **16** generates a Mach stem **54** symmetrically aligned along the axis thereof that is substantially conical in shape as defined by the conically shaped detonation front **52**. The angle generated by the detonation front **52** is indicated to be the angle equivalent to twice the angle *a* on FIGURE 3. This is the apex angle of the Mach stem **54**. The angle *a* is determined by the relative detonation front velocities in the first high explosive charge member **14** and the second high explosive charge member **16**.

However, at the intersection, that is the apex of the conical detonation front **52**, the detonation front generates two streams as indicated by the arrows **56** and **58**. The arrow **56** is generally moving backwardly with respect to the direction of movement of the detonation front **52** and the stream indicated by the arrow **58** is moving in the same direction axially as the detonation from **52** and the stream indicated by the arrow **58** generates the Mach stem **54**. It will be appreciated that as the material in the Mach stem **54** moves in a direction indicated by the arrow **58** along the axis **46**, the density of the gases contained therein remains substantially constant, but greater than behind the detonation front, but the size thereof constantly increases even though the angle *a* remains constant and therefore when the Mach stem **54** reaches the second end **30** of the second cylindrical high explosive charge member **14**, there is a comparatively high momentum value associated therewith. This high momentum value is utilized to move the projectile **40** in a direction indicated by the arrow **60**. In the preferred embodiment of applicant's invention, the width of the Mach stem indicated by the letter *w* at the second end **30** of the second high explosive charge member **16** is greater than the diameter of the projectile **40**, in order that edge losses which occur around the periphery of the Mach stem **54** cannot detract from the momentum exchange between the Mach stem **54** and the projectile **40**.

From the considerations heretofore set forth, it can be seen, as shown on FIGURE 3, that the Mach stem is properly defined as the intersection of the wave fronts in second high explosive charge member **16**. That is the Mach stem commences, in inertial space at the point designated **68** corresponding to a point on the axis of the second high explosive charge member **16** along the base surfaces **37** thereof. From a consideration of the velocities involved it will be noted that the detonation wave front **42***a* and **42***b* in the first cylindrical charge member **14** moves in a direction indicated by the arrow **44** at a first predetermined velocity. The detonation wave front **52** which, in the embodiment shown in FIGURE 3 is conical, intersecting and having its apex initially at the point **68**, moves in a direction indicated by the arrow **70** with a second predetermined velocity less than the first predetermined velocity. However, when the detonation front **52** in the second cylindrical charge member **16** has moved from the position indicated by **52***a* to the position indicated by **52***b*, it has traversed a certain distance indicated by the ledger *a*. In this same time interval, it will be appreciated, that the Mach stem has moved from the point **68** to the point **72** a greater distance than *a*. Thus, with respect to the inertial space point **68** the Mach stem has a velocity in the axial direction greater than the detonation front velocity in the second cylindrical charge member **16**.

As noted above material from the second cylindrical charge member **16** flows into the Mach stem in the direc-

tions indicated by the arrows **56** and **58**. That portion moving in the direction indicated by the arrow **58** is moving relative to the motion of the Mach stem and has, therefore, a total greater velocity with respect to the fixed inertial point **68** than the Mach stem velocity. Consequently, a Mach stem front **74** is generated that extends, in this embodiment of applicant's invention, across the conical detonation wave front, as shown on FIGURE 3. The velocity of the Mach stem front **74** with respect to the velocity of the Mach stem is greater and consequently there is a material build up between the detonation front and the Mach stem front, as indicated at **54**. The density of the gases and the portion designated **54** remains substantially constant, but because of the greater velocity of the Mach stem front **74** in the direction indicated by the arrow **76**, there is a constant increase in the momentum associated with the moving Mach stem.

By the time the Mach stem has moved to the point designated **80** there is a fairly large mass contained within the portion designated **54** and, because of the constantly increasing mass the momentum associated therewith is comparatively high and is imparted directly to the projectile **40** for acceleration thereof in a direction indicated by the arrow **60**. Thus, the constant angle Mach stem provides this high momentum portion designated by the numeral **54** for acceleration of the projectile **40**. It will be appreciated that only with the maintenance of a constant angle Mach stem can the higher momentum associated with the portion **54** be achieved. That is, with a variable angle Mach stem there is not the constant momentum build up necessary to provide the ultra-high velocity imparted to the projectile **40**. Thus, while the velocity of the detonation front **52** and the Mach stem front **74** are substantially constant for a given configuration, the constantly increasing mass in the portion **54** provides the high momentum that can provide the high energy for accelerating the projectile **40**.

While the above embodiment of applicant's invention describe the utilization of a constant angle Mach stem in a cylindrical configuration, it will be appreciated that such an arrangement may also be utilized with a rectangular configuration to provide a rod projectile accelerating arrangement. One such embodiment for achieving such a rod projectile arrangement is illustrated in FIGURES 4 and 5. As shown thereon, there is a charge means **100** comprised of a first high explosive charge member **102** in the form of a prism or block. The high explosive charge member **102** has an upper surface **104** and a lower surface **106** that are parallel and the sides **108** and **110** thereof as well as the end portions **112** and **114** are also respectively parallel.

The first high explosive charge member **102** has wall portions **116** defining a slot therethrough that extends from the upper surface **104** towards the lower surface **106**, but terminates a predetermined distance above the lower surface **106**. A second high explosive charge member **120** is positioned in the aperture formed by the walls **116** and has its external surfaces coplanar with the corresponding external surfaces of the first high explosive charge member **102**. An inert prism **122** is positioned in the aperture defined by the walls **116** of the first high explosive charge member **102** and is intermediate the base of the second high explosive charge member **120** and the first high explosive charge member **102**. A rod-like projectile that is to be accelerated, designated **124**, is positioned on the upper surface **126** of the second high explosive charge member **120**. A linear initiator **128** is coupled to the lower surface **106**, which surface **106** defines a preselected surface for ignition of the charge means **100** in this embodiment of applicant's invention, and is substantially aligned to be symmetrical with respect to the first high explosive charge member **102** and second high explosive charge member **120**.

The linear initiator may, for example, be fabricated from a material such as Du Pont "deta sheets," a registered trademark of E. I. Du Pont de Nemours & Company, Inc. and commonly termed a line wave generator.

When the linear initiator **128** is ignited, in a manner similar to that described above, a detonation front **130** is generated in the first high explosive charge member **102** and travels from the lower surface **106** thereof until it is intercepted by the wave shaper **122**. The wave shaper **122** performs the functions similar to the wave shaper means described above and, in this embodiment of applicant's invention, provides a detonation wave front **132** in the second high explosive charge member **120**. The wave shaper provides that the detonation wave front **132** intersects along a line **134** and thus provides a wedge shaped Mach stem. As the detonation front **132** traverses the second high explosive charge member **120**, there is a constant increase in the mass of the high density gas contained within the limits defined by the detonation front **132** and the Mach stem front **134** as it moves in the direction indicated by the arrow **136**. Since the detonation front velocity of the detonation front **130** in the first high explosive charge member **102** is greater than the detonation front velocity of the detonation front **132** in the second high explosive charge member **120**, the detonation front **130** constantly provides the detonation front **132** as it traverses the first high explosive charge member **102** in the direction indicated by the arrow **138**. When the detonation front **134** reaches the upper surface **126** of the second high explosive charge member **120**, the rod-like projectile **124** is accelerated because of the high momentum contained within the constant angle Mach stem. The mechanism of this acceleration is, of course, similar to that described above in connection with FIGURES 1, 2 and 3 except that in this embodiment of applicant's invention the Mach stem particles are contained within a wedge shaped configuration rather than within a conical configuration.

Wave shaping may be achieved by means other than an inert cylinder as described above. That is, the configuration and points of ignition of the high explosive charge member having the higher of the detonation front velocities may in itself provide the necessary wave shaping to provide the constant angle Mach stem. FIGURES 6 and 7 illustrate a prism embodiment wherein rectangular prisms similar to the rectangular prisms described above in connection with the embodiment of FIGURES 4 and 5 are utilized; however, a separate wave shaper means is not provided, since wave shaping is achieved by the unique points of application of the initiation of the detonation front. As shown on FIGURES 6 and 7 the charge means designated **150** is comprised of a first high explosive charge member **152** in the form of a rectangular prism having an upper surface **154**, a lower surface **156**, end surfaces **158** and **160** and side surfaces **162** and **164**. The first high explosive charge member **154** has walls **166** defining a slot therein extending from the upper surface **154** towards the lower surface **156**. Contained within the slot defined by the walls **166** there is a second high explosive charge member **168**. The first high explosive charge member **152** has a higher detonation front velocity than the second high explosive charge member **168**.

A rod-like projectile to be accelerated designated **170** is positioned on the upper surface **172** of the second high explosive charge member **168**. Thus, this prism configuration of the first high explosive charge member **152** and second high explosive charge member **168** and rod-like projectile **170** is similar to the charge means **100** described above in connection with FIGURES 4 and 5, except that there is not included any separate inert wave shaper such as the wave shaper **122**.

The intersection of the lower surface **156** with the side surfaces **162** and **164** are the lines upon which the preselected surface portions of the charge means **150** are ignited and may be ignited simultaneously along the entire length thereof by the linear initiators **174** which may be similar to the linear initiator **128** shown in FIGURES

4 and 5. In this embodiment they are in the form of triangular sections of Deta Sheet terminating in a point **176** which may be initiated by a detonator or similar means as described above.

When the linear initiators **174** are initiated from the point **176** by the detonator **178**, the detonation front travels linearly therealong and ignites the entire line segment defined by the above-mentioned intersection of the lower surface **156** and side surfaces **162** and **163** of the first high explosive charge member **152**. Detonation front then moves through the high explosive charge member toward the second high explosive charge member **168**, impinges simultaneously along the lower corners **180** and **182** thereof. Since the linear velocity of the detonation front in the first high explosive charge member **152** is greater than in the second high explosive charge member **168**, a constant angle Mach stem is generated and in this embodiment of applicant's invention it is also in a wedge-shaped form as defined by the intersecting detonation front **184** in the second high explosive charge member **168** and the Mach stem front **186**. This moves in the direction indicated by the arrow **188** towards the upper surface **172** of the second high explosive charge member **168** and upon reaching the surface **172** the high momentum associated with the material in the constant angle Mach stem accelerates the rod-like projectile **170** in a manner described above.

As above described applicant's improved constant angle Mach stem has been shown as utilized to provide acceleration of a projectile. However, it will be appreciated that applicant's invention herein may also be utilized to provide a shaped charge jet. One such embodiment for a cylindrical shape charge jet is shown in FIGURE 8. As shown thereon there is a charge means generally designated **200**, comprised of a first cylindrical high explosive charge member **202** having an upper surface **204** and a lower surface **206** and walls **208** defining an aperture therein extending from the first surface **204** towards the second surface **206**. Thus, this first cylindrical high explosive charge member **202** is similar to the first cylindrical high explosive charge member **14** described above.

Positioned within the aperture defined by the walls **208** is a tubular second high explosive charge member **210** and an inert cylinder **212** at the base of the aperture defined by the walls **208**. A tubular metallic liner **212** is positioned within the tubular second high explosive charge member **210** and the outer peripheral walls of the tubular metallic liner **212** are continuous to the inner peripheral walls of the tubular high explosive charge member **210**.

In this embodiment of applicant's invention axial portions of the lower surface **206** are the preselected surface portions for igniting the charge means **200** to provide a detonation front. When these surfaces are ignited by the igniter **214** in the manner described above, a detonation front progresses through the first high explosive charge member **202** from the bottom surface **206** towards the top surface **204**. However, in the manner described above in connection with the embodiment in FIGURES 1, 2 and 3, a detonation front **214** is generated in the second high explosive charge member **210**. It will be appreciated that the detonation front velocity in the first high explosive charge member **202** is greater than the detonation front velocity in the tubular high explosive charge member **210**.

However, in this embodiment of applicant's invention, the tubular metallic liner **212** prevents the intersection of the detonation fronts **214**, since the tubular second high explosive charge member **210** is not a solid cylinder. However, the detonation fronts **214** intercept with the tubular metallic liner **212** and provide a constant angle Mach stem at the intersection of the detonation front **214** and the metallic liner **212**. Thus, there is a collapsing of the metallic liner **212** to form a jet in a manner analogous to the formation of the typical shaped charge jet. However, in this embodiment of applicant's invention the constant angle Mach stem as generated by the detonation fronts **214** provide the exceptionally high velocity to be imparted to the particles comprising the jet because of the constant increase in the momentum associated with the particles between the detonation front **214**, the Mach stem front **216** and the metallic tubular liner **212**. Thus, the jet formed by the collapsing of the metallic tubular liner **212** is forced outwardly in a direction indicated by the arrow **218** at a comparatively high velocity because of the high momentum associated with the small constant angle Mach stem.

While the embodiment shown in FIGURE 8 is for a cylindrical configuration, it will be appreciated that a jet may also be provided in a rectangular prism configuration to provide a directed sheet type of warhead.

FIGURES 9 and 10 illustrate such an embodiment of applicant's invention. As shown on FIGURES 9 and 10 there is a charge means **220** comprised of a first high explosive charge member **222** in the form of a rectangular prism having substantially parallel top and bottom walls **224** and **226**, respectively, substantially parallel side walls **228** and **230**, respectively, and substantially parallel end walls **232** and **234**, respectively. The first high explosive charge member **222** has walls **236** defining a slot therein extending a preselected distance from the upper surface **224** thereof towards the lower surface **226**.

A pair of second high explosive charge members **238***a* and **238***b*, which are identical, are placed in the slot defined by the wall **236** in a spaced apart relationship and a pair of metallic plates **240***a* and **240***b* are placed in a spaced apart relationship against the second high explosive charge members **238***a* and **238***b*, respectively, in a manner indicated in FIGURES 9 and 10. End plates (not shown) may be included if desired to close the ends of the charge means **220**.

The lower surface **226** of the first high explosive charge member **222** contains the preselected surface areas for ignition of the charge means **220**. When a wave shaper **242** is provided in the base of the aperture defined by the wall **236** a linear initiator **244** symmetrically aligns with the first high explosive charge member **222** and second high explosive charge members **238***a* and **238***b* may be utilized in a manner analogous to that described above in connection with the embodiment shown in FIGURE 4 and FIGURE 5. However, it will be appreciated, that the wave shaper **242**, which is formed from an inert rectangular prism, may be eliminated and linear initiators similar to those described in connection with the embodiments shown in FIGURES 6 and 7 utilized to ignite the edges **246** and **248** of the first high explosive charge member **222** to provide the constant angle Mach stem.

When the charge means **220** is ignited, a constant angle Mach stem is formed in the second high explosive charge members **238***a* and **238***b* and is a substantially wedge shaped configuration and collapses the pair of plates **240***a* and **240***b* towards each other to define a directed sheet warhead provided with a high velocity because of the high momentum associated with the material contained within the small constant angle Mach stem.

In all the above embodiments of applicant's invention, it will be appreciated, there is provided two different high explosive charge members. The first high explosive charge member always has a detonation front velocity greater than the second high explosive charge member and a wave shaper which may be the form of an inert object, or in the form of the configuration of the two explosive charge members themselves is utilized to provide the particular detonation front configuration ncessary to generate a small constant angle Mach stem. The mechanism of the constant angle Mach stem is such that the momentum associated with the particles contained within the constant angle Mach stem continually increases during the traverse of the constant angle Mach stem through the second high explosive charge member. Thus, the increase in momentum provides a high force for acceleration of a particle or jet depending upon the configuration.

Applicant has found that HMX, PBX or similar explosives may be utilized as the first high explosive charge member since they have detonation front velocities on the order of 8500 to 9000 meters per second. Correspondingly, Comp. B or Comp. C, having detonation front velocities on the order of 7500 meters per second may be utilized as the second high explosive charge member.

Those skilled in the art may find many variations and adaptations of applicant's invention. The following claims are intended to cover all such variations and adaptations falling within the true scope and spirit of applicant's invention herein.

For example, the embodiment illustrated in FIGURE 11 combines the features shown in the embodiment of FIGURES 9 and 10 with the embodiment of FIGURES 6 and 7. Thus, as shown in FIGURE 11, there is another variation of the directed sheet warhead embodiment, generally designated **250** comprised of a charge means **252** having a first high explosive charge member **254** and a second high explosive charge member **256**. In the embodiment shown in FIGURE 11 the first high explosive charge **252** and second high explosive charge **256** are in rectangular prism form, and FIGURE 11 is an end view thereof.

A pair of rectangular metallic plates **258** are coupled to the second high explosive charge member **256** and are in spaced apart relationship. A line initiator **260** is coupled to an external peripheral edge of the first high explosive charge member **254** to provide ignition thereof. The line initiators **260** may b efabricated from "Detasheet" and identical to the linear initiators **174** shown in FIGURES 6 and 7. The linear initiator **260** may be ignited by the detonator **262** to provide detonation of the charge means **250**.

As described above in connection with FIGURES 9 and 10, a constant angle Mach stem is generated in the second high explosive charge member **256** to form a directed sheet warhead from the collapsing metallic plates **258**. The charge means **252** may be held together in preferred relationship shown on FIGURE 11 by any desired structural arrangement. The detonation front velocity in the first high explosive charge member **254** is, of course, greater than the detonation front velocity in the second high explosive charge member **256**.

This concludes the description of applicant's invention. What is desired to be secured by Letters Patent of the United States is:

What is claimed is:

1. In combination:

charge means having preselected surface portions for ignition thereof to generate detonation front emanating therefrom for travel through said charge means for said preselected surface portion;

said charge means comprises:

a first high explosive charge member having a first detonation front velocity and having said preselected surface portions thereon;

a second high explosive charge member in detonation relationship to said first high explosive charge member and having a second detonation front velocity less than said first detonation front velocity;

means in said charge means intercepting said detonation front to provide an intersecting detonation front combination for generating a substantially constant angle in the intersection of said detonation front during at least a predetermined portion of the travel of said detonation front through said charge means;

said detonation front generates a Mach stem in said charge means and said Mach stem having an increasing momentum during said preselected portions of travel of said detonation front through said charge means;

a projectile means positioned in said charge means to be accelerated by the material in said Mach stem to regions external said charge means; and

said projectile means is positioned adjacent said second high explosive charge member.

2. The arrangement defined in claim **1** wherein:

said first high explosive charge member has a pair of spaced apart end surfaces, and wall portions defining an aperture extending from a first of said end surfaces into said first high explosive charge member a preselected distance from said first end surface thereof, and said aperture having a base portion spaced apart from a second end surface of said first high explosive charge member;

said second high explosive charge member is positioned in said aperture and has a first end substantially coplanar with said first end surface of said first high explosive charge member and a second end spaced apart from said base portion of said aperture; and

said means comprises a wave shaper means comprising an inert member in said aperture intermediate said base portion of said aperture and said second high explosive charge member.

3. The arrangement defined in claim **1** wherein said Mach stem defines a substantially constant angle cone.

4. The arrangement defined in claim **3** wherein:

said first high explosive charge member comprises a first cylindrical high explosive charge member having a first end and a second end, and having walls defining an aperture extending from said first end towards said second end and said aperture having a base portion spaced from said second end of said first high explosive charge member;

said second high explosive charge member comprises a second cylindrical high explosive charge member positioned in said aperture and having a first end substantially coplanar with said first end of said first high explosive charge member and a second end spaced from said base portion of said aperture;

said wave shaper means comprises an inert cylindrical member intermediate said base portion of said aperture and said second end of said second cylindrical high explosive charge member;

said preselected ignition surface portions comprise said second end of said first cylindrical high explosive charge member; and

said projectile means is positioned on said first end of said second high explosive charge member.

5. The arrangement defined in claim **1** wherein said Mach stem is substantially wedge shaped.

6. The arrangement defined in claim **5** wherein:

said first high explosive charge member comprises a quadrilateral first high explosive charge member having substantially parallel top and bottom surfaces, substantially parallel end surfaces, and substantially parallel side surfaces, and walls defining a slot extending from a first end surface toward a second end surface and extending a preselected distance into said first high explosive charge member from said top surface thereof and said slot having a base portion spaced from said bottom surface of said first high explosive charge member;

said second high explosive charge member comprises a second quadrilateral high explosive charge member positioned in said slot in said first high explosive charge member and having to top substantially coplanar with said top surface of said first high explosive charge member and a bottom spaced from said base portion of said slot;

said projectile is positioned adjacent said top of said second quadrilateral high explosive charge member; and

said preselected surface portions for ignition comprise the edges defined by the intersections of said sides

and said bottom surfaces of said first quadrilateral high explosive charge member.

7. In combination:

charge means having preselected surface portions for ignition thereof to generate detonation front emanating therefrom for travel through said charge means from said pre-selected surface portion;

means in said charge means intercepting said detoation front to provide an intersecting detonation front combination for generating a substantially constant angle in the intersection of said detonation front during at least a predetermined portion of the travel of said detonation front through said charge means;

and said charge means comprises:

a first cylindrical high explosive charge member having a first end and a second end, and walls defining an aperture extending axially inwardly a preselected distance from said first end towards said second end, and said aperture having a base portion spaced apart from said second end of said first cylindrical high explosive charge member, and said first high explosive charge member having a first detonation front velocity;

a second tubular high explosive charge member positioned in said aperture of said first cylindrical high explosive charge member and having a first end substantially coplanar with said first end of said first high explosive charge member, and a second end spaced apart from said base portion of said aperture, and having a second detonation front velocity less than said first detonation front velocity;

a tubular metallic liner positioned in said second high explosive charge member having outer peripheral wall portions contiguous with inner peripheral wall portions of said second tubular high explosive charge member and said tubular metallic liner extending from said first end to said second end of said second tubular high explosive charge member;

said means comprises an inert cylinder member in said aperture of said first cylindrical high explosive charge member intermediate said base portion thereof and said second end of said second tubular high explosive charge member; and

said preselected surface portions for ignition comprise said second end of said first cylindrical high explosive charge member.

8. In combination:

charge means having preselected surface portions for ignition thereof to generate detonation front emanating therefrom for travel through said charge means from said preselected surface portion;

means in said charge means intercepting said detonation front to provide an intersecting detonation front combination for generating a substantially constant angle in the intersection of said detonation front during at least a predetermined portion of the travel of said detonation front through said charge means;

said charge means comprises a first high explosive charge member in the form of a rectangular prism, and having walls defining a slot therein extending a preselected distance from a first end thereof towards a second end thereof;

a pair of second high explosive charge members in the form of rectangular prisms contained within said slot in said first high explosive charge member in a spaced apart relationship;

a pair of plate means in spaced apart relationship adjacent to said pair of second high explosive charge means;

said preselected surface portions for ignition of said charge means comprise edge portions of said base of said first high explosive charge member;

a pair of linear initiators coupled to said edges of said first high explosive charge member for initiation of a detonation wave therealong; and

means for detonating said linear initiator.

9. In combination:

charge means having preselected surface portions for ignition thereof to generate detonation front emanating therefrom for travel through said charge means from said preselected surface portion;

means in said charge means intercepting said detonation front to provide an intersecting detonation front combination for generating a substantially constant angle in the intersection of said detonation front during at least a predetermined portion of the travel of said detonation front through said charge means;

said charge means comprises a first high explosive charge member in the form of a rectangular prism, and having walls defining a slot therein extending a preselected distance from a first end thereof towards a second end thereof;

a pair of second high explosive charge members in the form of rectangular prisms contained within said slot in said first high explosive charge member in a spaced apart relationship;

a pair of plate means in spaced apart relationship adjacent to said pair of second high explosive charge means;

an inert rectangular prism wave shaper contained within said slot in said first high explosive charge member;

said preselected surface portions for ignition comprise symmetrical centralized surface portions of said base of said first high explosive charge member; and

a linear initiator for initiating a detonation front in said first high explosive charge member along said preselected ignition surface.

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VERLIN R. PENDEGRASS, Primary Examiner

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