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(54) **ANTI-MISSILE MISSILES**

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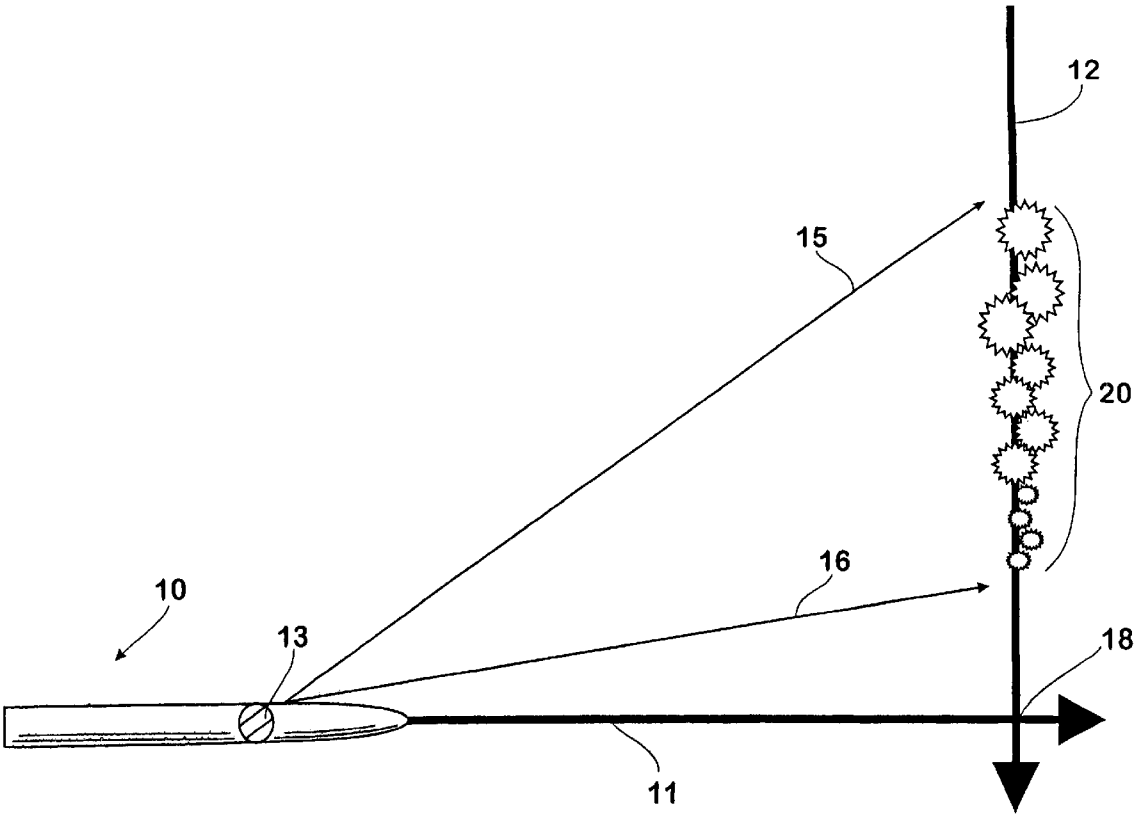
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(57) **ABSTRACT**

An anti-missile missile (**10**) includes a missile configured to track and intercept an incoming missile travelling along path (**12**). Missile (**10**) includes at least one barrel assembly (**13**) having a multiplicity of projectiles stacked axially within barrel assembly (**13**), together with discrete selectively ignitable propellant charges for propelling the multiplicity of projectiles sequentially through the muzzle of barrel assembly (**13**). The multiplicity of projectiles produce a fragment column (**20**) along path (**12**) to destroy the incoming missile. Alternatively, anti-missile missile (**10**) can be guided to produce a direct hit at point (**18**) on the incoming missile. Barrel assembly (**13**) can include an aiming mechanism so that barrel assembly (**13**) can be rotated through sector (**15, 16**) to target path (**12**).



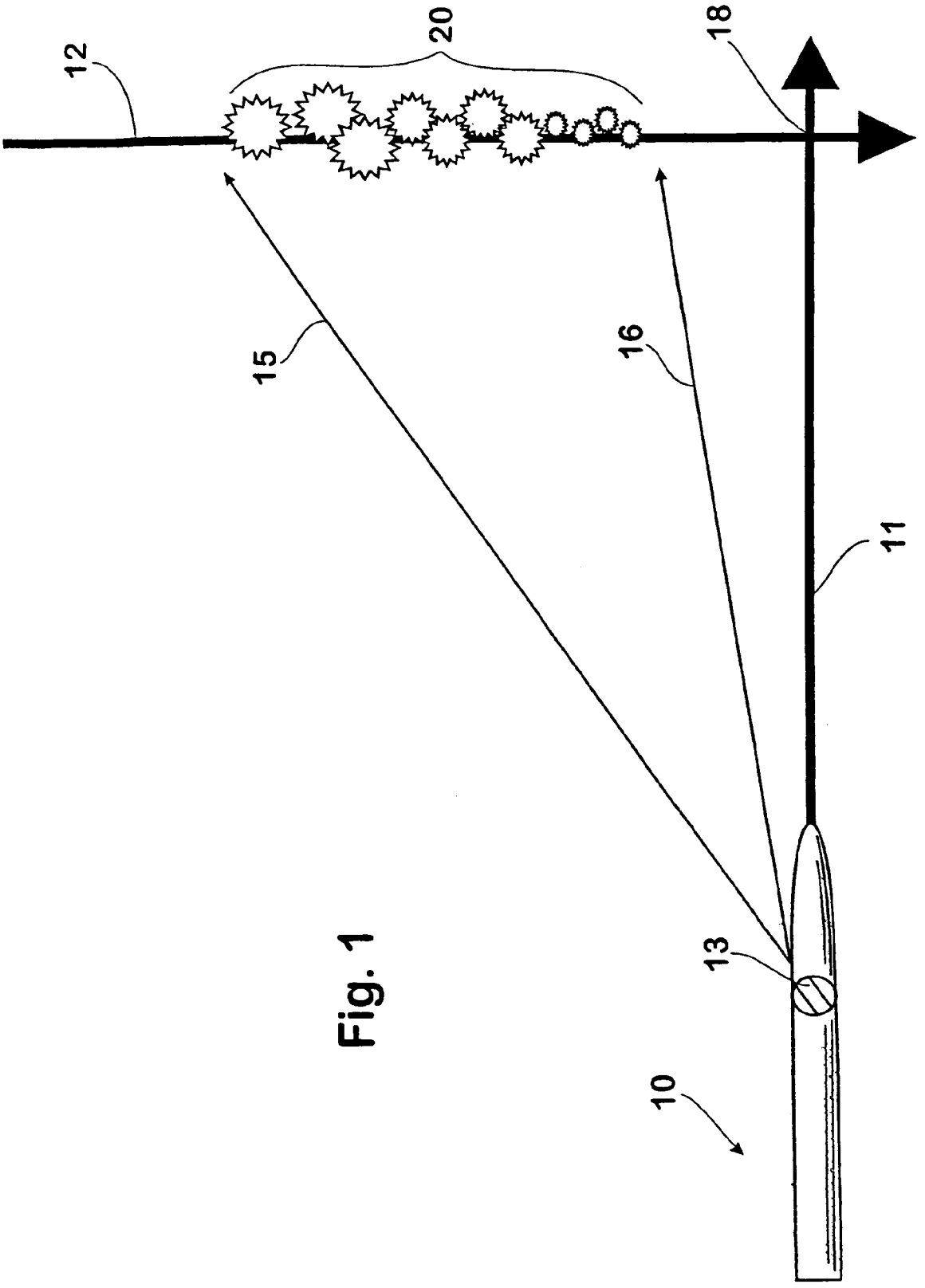


Fig. 1

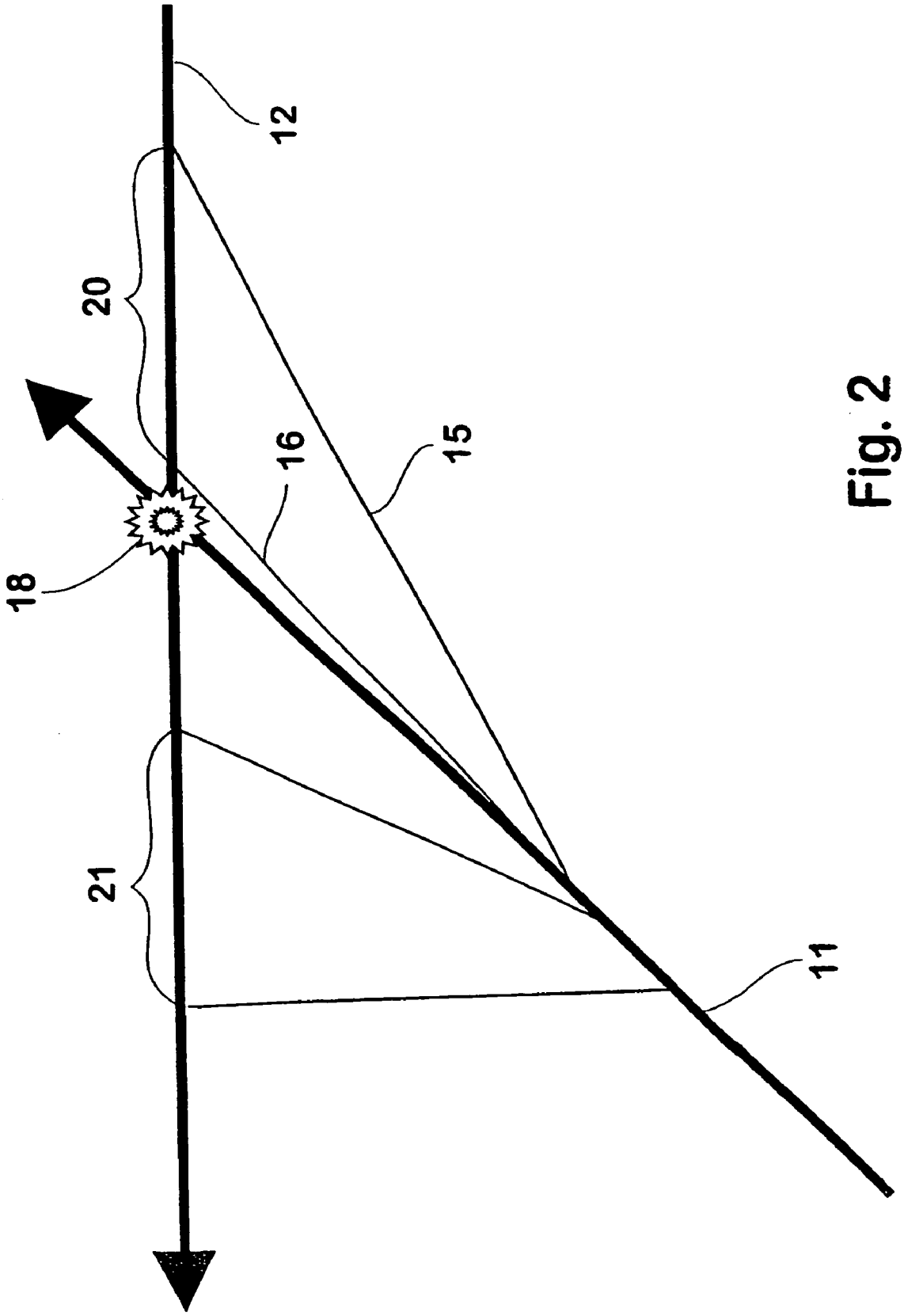


Fig. 2

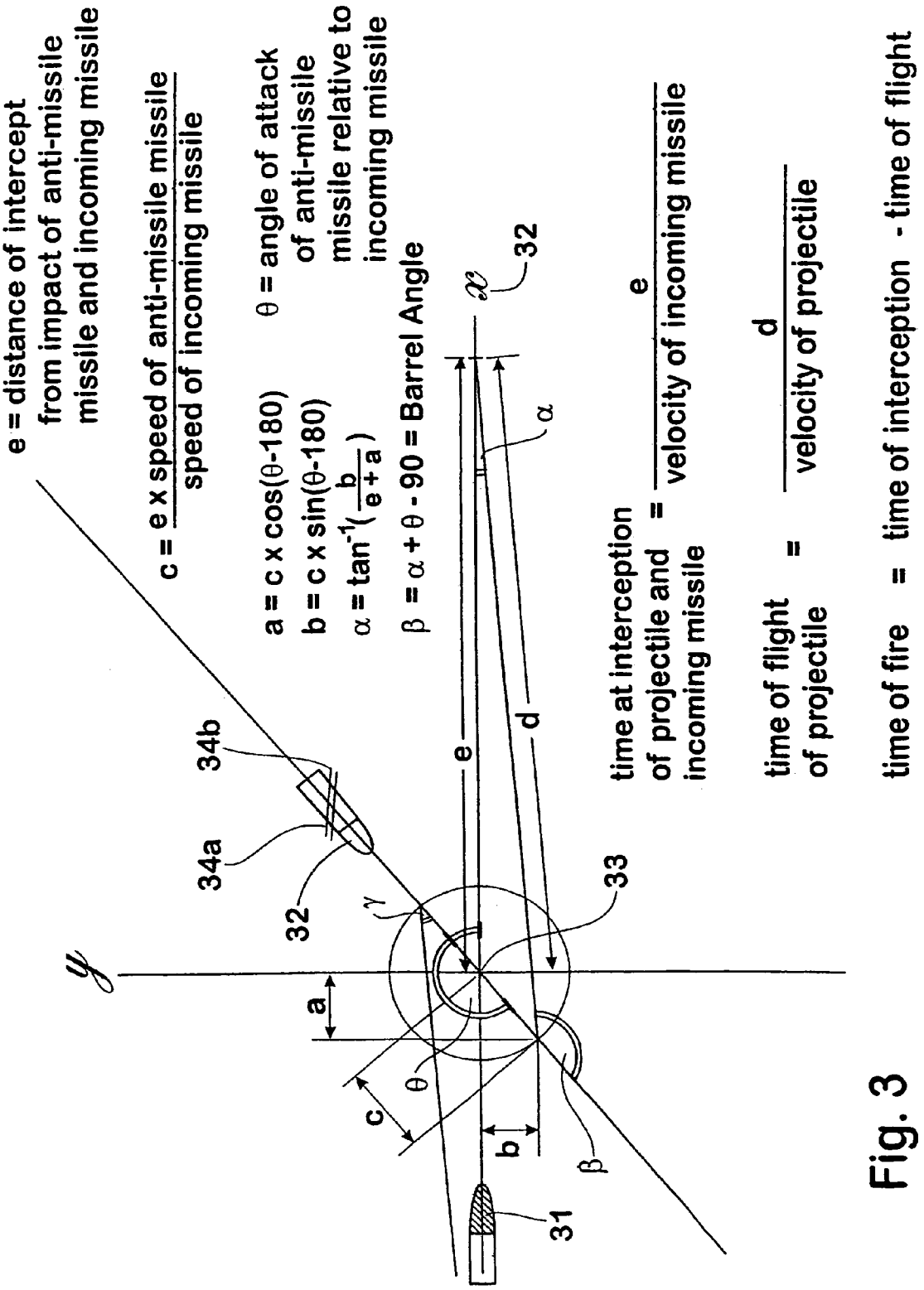

e = distance of intercept from impact of anti-missile missile and incoming missile
c = e x speed of anti-missile missile / speed of incoming missile
a = c x cos(θ-180)
b = c x sin(θ-180)
α = tan⁻¹(b/(e+a))
β = α + θ - 90 = Barrel Angle
θ = angle of attack of anti-missile missile relative to incoming missile
time at interception of projectile and incoming missile = e / velocity of incoming missile
time of flight of projectile = d / velocity of projectile
time of fire = time of interception - time of flight
34b
34a
32
γ
33
e
d
α
32
a
θ
c
b
β
31

Fig. 3

ANTI-MISSILE MISSILES

[0001] This invention relates to anti-missile missiles and to a method of destroying or incapacitating an incoming missile.

[0002] Missiles generally move at high speed towards a target and are thus extremely difficult to intercept in order to destroy or incapacitate. Whilst it may be possible to deploy a multiplicity of defensive rounds from the target to intercept the incoming missile, this may not be desirable as the initial or sole response to the threat. Such interception of the incoming missile is generally more effective close to the target and as such does not permit secondary responses if the initial response fails to destroy or incapacitate the incoming missile. Further the incoming missile may still be a significant threat to the target if it is in fact destroyed or incapacitated close to the target. For example, any destruction of the incoming missile close to the target may still result in an explosion of sufficient magnitude to damage the target, production of fragments of the incoming missile that have sufficient momentum to damage the target or may distribute hazardous waste or the like over the target.

[0003] Early detection of an incoming missile permits counter-measures in the form of anti-missile missiles to be deployed. Anti-missile missiles rely on impacting with the incoming missile or exploding in the vicinity of the incoming missile. The chances of an anti-missile missile successfully impacting with an incoming missile, even with sophisticated navigation and directional control, are low due to the smallness of the incoming missile and its relative approach speed. The ability of an anti-missile missile to make a late correction of flight path in response to a late deviation of the incoming missile is limited.

[0004] Anti-missile missiles that explode in the vicinity of the incoming missile provide a multiplicity of fragments in the path of the incoming missile or, if close enough, can destroy or incapacitate the incoming missile.

[0005] We have now found that by employing barrel assemblies having a plurality of projectiles stacked axially within the barrels together with discrete selectively ignitable propellant charges for propelling the projectiles sequentially through the muzzle of the barrels located on an anti-missile missile, the chances of successfully destroying or incapacitating an incoming missile is substantially improved.

[0006] Accordingly, in one embodiment, the present invention provides an anti-missile missile including a missile configured to intercept an incoming missile wherein said anti-missile missile further includes at least one barrel assembly having a multiplicity of projectiles stacked axially within the at least one barrel assembly together with discrete selectively ignitable propellant charges for propelling the multiplicity of projectiles sequentially through the muzzle of the at least one barrel assembly.

[0007] In a second embodiment, the present invention provides a method of destroying or incapacitating an incoming missile comprising the steps of launching an anti-missile missile wherein said anti-missile missile includes a missile configured to intercept said incoming missile and wherein said anti-missile missile further includes at least one barrel assembly having a multiplicity of projectiles stacked axially within the at least one barrel assembly together with discrete selectively ignitable propellant charges for propelling the multiplicity of projectiles sequentially through the muzzle of the at least one barrel and sequentially firing said multiplicity of projectiles at said incoming missile.

[0008] Incoming missiles, such as high altitude ballistic missiles, are widely employed as long-range strike weapons as they are very effective and difficult to detect in time for adequate defences to be actioned. Out-of-atmosphere ballistic missiles travel at extremely high speed and are extremely difficult to intercept in a hit-to-kill mode that relies on the anti-missile missile striking, or detonating in the immediate vicinity to the incoming missile. In some embodiments the present invention provides an anti-missile missile that may improve the likelihood of destroying or incapacitating an out-of-atmosphere ballistic missile. The present invention also has application in the destruction or incapacitation of other missiles including surface-to-air missiles, air-to-surface missiles, air-to-air missiles, surface-to-surface missiles, ship-to-ship missiles, air-to-ship missiles and other combinations thereof. The exact nature of the incoming missile is not narrowly critical to the definition of the present invention.

[0009] The anti-missile missile, or defensive missile, may be of any convenient type capable of intercepting the incoming missile. Desirably the anti-missile missile is capable of impacting with, or exploding adjacent to, the incoming missile and destroying or incapacitating the incoming missile. Typically an anti-missile missile will include an airframe, a propulsion system, a guidance system and optionally an explosive for destroying or incapacitating an incoming missile.

[0010] The anti-missile missile typically includes a guidance system that tracks the path of the incoming missile and maintains the anti-missile missile on a path that will intercept the incoming missile. The guidance system may incorporate a path sensing means that is associated with an aiming mechanism for the at least one barrel assembly. The guidance system preferably accommodates late aiming corrections that may be made to the barrel assemblies for accurately propelling the multiplicity of projectiles into the path of the incoming missile. Even if the path of the anti-missile missile is unable to be corrected, by propelling the multiplicity of projectiles into its path increases the chances of disabling the incoming missile.

[0011] The anti-missile missile is configured to intercept the incoming missile. The configuration of the anti-missile missile is not narrowly critical to the present invention provided that the anti-missile missile is capable of carrying at least one barrel assembly and preferably a least one barrel assembly that is capable of rotation to target the path of the incoming missile.

[0012] The anti-missile missile may be launched by any convenient means, such as from a land based launch base, a ship, an aircraft or other.

[0013] The anti-missile missile includes at least one barrel assembly having a multiplicity of projectiles stacked axially within the at least one barrel assembly together with discrete selectively ignitable propellant charges for propelling the multiplicity of projectiles sequentially through the muzzle of the at least one barrel.

[0014] Barrel assemblies including a barrel; a multiplicity of projectiles axially disposed within the barrel for operative

sealing engagement with the bore of the barrel, and discrete propellant charges for propelling respective projectiles sequentially through the muzzle of the barrel may be used in the present invention. Such barrel assemblies are described in International Patent Application Nos. PCT/AU94/00124, PCT/AU96/00459 and PCT/AU97/00713.

[0015] The projectile may be round, conventionally shaped or dart-like and the fins thereof may be off-set to generate a stabilising spin as the dart is propelled from a barrel which may be a smooth-bored barrel.

[0016] The projectile charge may be form as a solid block to operatively space the projectiles in the barrel or the propellant charge may be encased in metal or other rigid case which may include an embedded primer having external contact means adapted for contacting an pre-positioned electrical contact associated with the barrel. For example the primer could be provided with a sprung contact which may be retracted to enable insertion of the cased charge into the barrel and to spring out into a barrel aperture upon alignment with that aperture for operative contact with its mating barrel contact. If desired the outer case may be consumable or may chemically assist the propellant burn. Furthermore an assembly of stacked and bonded or separate cased charges and projectiles may be provide for reloading a barrel.

[0017] Each projectile may include a projectile head and extension means for at least partly defining a propellant space. The extension means may include a spacer assembly which extends rearwardly from the projectile head and abuts an adjacent projectile assembly.

[0018] The spacer assembly may extend through the propellant space and the projectile head whereby compressive loads are transmitted directly through abutting adjacent spacer assemblies. In such configurations, the spacer assembly may add support to the extension means that may be a thin cylindrical rear portion of the projectile head. Furthermore the extension means may form an operative sealing contact with the bore of the barrel to prevent burn leakage past the projectile head.

[0019] The spacer assembly may include a rigid collar which extends outwardly to engage a thin cylindrical rear portion of the malleable projectile head inoperative sealing contact with the bore of the barrel such that axially compressive loads are transmitted directly between spacer assemblies thereby avoiding deformation of the malleable projectile head.

[0020] Complementary wedging surfaces may be disposed on the spacer assembly and projectile head respectively whereby the projectile head is urged into engagement with the bore of the barrel in response to relative axial compression between the spacer means and the projectile head. In such arrangement the projectile head and spacer assembly may be loaded into the barrel and there after an axial displacement is caused to ensure good sealing between the projectile head and barrel. Suitably the extension means is urged into engagement with the bore of the barrel.

[0021] The projectile head may define a tapered aperture at its rearward end into which is received a complementary tapered spigot disposed on the leading end of the spacer assembly, wherein relative axial movement between the projectile head and the complementary tapered spigot causes a radially expanding force to be applied to the projectile head.

[0022] The barrel may be non-metallic and the bore of the barrel may include recesses which may fully or partly accommodate the ignition means. In this configuration the barrel houses electrical conductors which facilitate electrical communication between the control means and ignition means. This configuration may be utilised for disposable barrel assemblies which have a limited firing life and the ignition means and control wire or wires therefor can be integrally manufactured with the barrel.

[0023] A barrel assembly may alternatively include ignition apertures in the barrel and the ignition means are disposed outside the barrel and adjacent the apertures. The barrel may be surrounded by a non-metallic outer barrel which may include recesses adapted to accommodate the ignition means. The outer barrel may also house electrical conductors which facilitate electrical communication between the control means and ignition means. The outer barrel may be formed as a laminated plastics barrel which may include a printed circuit laminate for the ignition means.

[0024] The barrel assembly may have adjacent projectiles that are separated from one another and maintained in spaced apart relationship by locating means separate from the projectiles, and each projectile may include an expandable sealing means for forming an operative seal with the bore of the barrel. The locating means may be the propellant charge between adjacent projectiles and the sealing means suitably includes a skirt portion on each projectile which expands outwardly when subject to an in-barrel load. The in-barrel load may be applied during installation of the projectiles or after loading such as by tamping to consolidate the column of projectiles and propellant charges or may result from the firing of an outer projectile and particularly the adjacent outer projectile.

[0025] The rear end of the projectile may include a skirt about an inwardly reducing recess such as a conical recess or a part-spherical recess or the like into which the propellant charge portion extends and about which rearward movement of the projectile will result in radial expansion of the projectile skirt. This rearward movement may occur by way of compression resulting from a rearward wedging movement of the projectile along the leading portion of the propellant charge it may occur as a result of metal flow from the relatively massive leading part of the projectile to its less massive skirt portion.

[0026] Alternatively the projectile may be provided with a rearwardly divergent peripheral sealing flange or collar which is deflected outwardly into sealing engagement with the bore upon rearward movement of the projectile. Furthermore the sealing may be effected by inserting the projectiles into a heated barrel which shrinks onto respective sealing portions of the projectiles. The projectile may comprise a relatively hard mandrel portion located by the propellant charge and which cooperates with a deformable annular portion may be moulded about the mandrel to form a unitary projectile which relies on metal flow between the nose of the projectile and its tail for outward-expansion about the mandrel portion into sealing engagement with the bore of the barrel.

[0027] The projectile assembly may include a rearwardly expanding anvil surface supporting a sealing collar thereabout and adapted to be radially expanded into sealing

engagement with the barrel bore upon forward movement of the projectile through the barrel. In such a configuration it is preferred that the propellant charge have a cylindrical leading portion which abuts the flat end face of the projectile.

[0028] The projectiles may be adapted for seating and/or location within circumferential grooves or by annular ribs in the bore or in rifling grooves in the bore and may include a metal jacket encasing at least the outer end portion of the projectile. The projectile may be provided with contractible peripheral locating rings which extend outwardly into annular grooves in the barrel and which retract into the projectile upon firing to permit its free passage through the barrel.

[0029] The electrical ignition for sequentially igniting the propellant charges of a barrel assembly may preferably include the steps of igniting the leading propellant charge by sending an ignition signal through the stacked projectiles, and causing ignition of the leading propellant charge to arm the next propellant charge for actuation by the next ignition signal. Suitably all propellant charges inwardly from the end of a loaded barrel are disarmed by the insertion of respective insulating ruses disposed between normally closed electrical contacts.

[0030] Ignition of the propellant may be achieved electrically or ignition may utilise conventional firing pin type methods such as by using a centre-fire primer igniting the outermost projectile and controlled consequent ignition causing sequential ignition of the propellant charge of subsequent rounds. This may be achieved by controlled rearward leakage of combustion gases or controlled burning of fuse columns extending through the projectiles.

[0031] In another form the ignition is electronically controlled with respective propellant charges being associated with primers which are triggered by distinctive ignition signals. For example the primers in the stacked propellant charges may be sequenced for increasing pulse width ignition requirements whereby electronic controls may selectively send ignition pulses of increasing pulse widths to ignite the propellant charges sequentially in a selected time order. Preferably however the propellant charges are ignited by a set pulse width signal and burning of the leading propellant charge arms the next propellant charge for actuation by the next emitted pulse.

[0032] Suitably in such embodiments all propellant charges inwardly from the end of a loaded barrel are disarmed by the insertion of respective insulating fuses disposed between insertion of respective insulating fuses disposed between normally closed electrical contacts, the fuses being set to burn to enable the contacts to close upon transmission of a suitable triggering signal and each insulating fuse being open to a respective leading propellant charge for ignition thereby.

[0033] A number of projectiles can be fired simultaneously, or in quick succession, or in response to repetitive manual actuation of a trigger, for example. In such arrangements the electrical signal may be carried externally of the barrel or it may be carried through the superimposed projectiles which may clip on to one another to continue the electrical circuit through the barrel, or abut in electrical contact with one another. The projectiles may carry the control circuit or they may form a circuit with the barrel.

[0034] The one or more barrel assemblies may be carried by the defensive missile and respective guns may be arranged to scatter or deploy fragments to the path of the incoming missile both before and after the predicted missile to missile engagement position. Alternatively a single barrel assembly may be utilised to propel fragments to the path to and from the predicted missile to missile engagement position. The barrel assembly may also simultaneously fire rounds in opposite directions so as to minimise any change of flight path of the anti-missile missile.

[0035] Preferably the projectile may be a grenade-like projectile that is capable of detonating in the path of the incoming missile so as to create a column of fragments through which the incoming missile must pass. The likelihood of destroying or incapacitating the incoming missile is thereby increased.

[0036] The, or each, projectile may be fired from a rifled barrel and may use spin count for gauging the distance/timing to the flight path. In the case of multiple projectiles fired from barrel assemblies of the type described, the spin count may be preset for each projectile and the time delay in the firing sequence may provide the desired separation or intermingling of deployed fragments along the flight path. Alternatively the timing mechanism may be adjustable in flight with an appropriate input provided by incoming missile path sensing means.

[0037] Aiming corrections to the barrel assemblies may be effected by a rotation on mountings on the defensive missile about its axis and the mountings may be themselves be rotatable about the missile axis. Such corrections may be more readily achieved than a late deflection of the defensive missile's flight path. Such aiming corrections may be monitored and effected over a relatively long approach period thereby maintaining a relatively slow corrective action to achieve on-target firing of the gun or guns.

[0038] The barrel assembly or barrel assemblies may fire a projectile which explodes when in the desired missile path to scatter fragments or deploy fragments about the incoming missile path so as to increase the possibility of collision between the incoming missile and a fragment carried thereto by the defensive missile. The fragments may have sufficient mass such that a collision therewith would at least partially disable the incoming missile or the fragments may be explosive fragments or charges. Suitably the projectiles are fired or deployed to a path adjacent the predicted missile to missile engagement position so that time lapses between firing and deployment of the fragments or missile to missile engagement are minimal, minimising flight path variations of the anti-missile missile and incoming missile and projectiles.

[0039] We have found that for any given system, an incoming missile having a known velocity, an anti-missile missile having a known velocity, barrel assemblies having known muzzle velocities, the angle at which the barrel assemblies is to be directed is constant irrespective of how long and where a fragment column is desired. This is applicable to fragment columns before and after the predicted impact position of the incoming missile and the anti-missile missile with the direction of the barrel assemblies being offset by 180 degrees. This feature of the present invention is particularly advantageous as it permits equal and opposite firing to be performed to establish fragment columns before and after the predicted impact position of the incoming missile and the anti-missile missile with minimal effect on the direction of the anti-missile missile.

[0040] The methods of defence against an incoming missile as variously described above constitute further aspects of this invention.

[0041] In order that this invention may be more readily understood and put into practical effect, reference will now be made to the accompanying drawings and examples that illustrate a typical embodiment of this invention, wherein:—

[0042] **FIG. 1** diagrammatically illustrates a typical anti-missile missile and its operation, and

[0043] **FIG. 2** illustrates a typical trajectory analysis.

[0044] **FIG. 3** illustrates an approximate analysis of the trajectory of the respective missiles and the projectiles in an out-of-atmosphere environment.

[0045] **FIG. 1** provides a diagrammatic illustration of a defensive missile **10** travelling along an intersection path **11** towards the path **12** of an incoming ballistic missile. In this embodiment, the paths **11** and **12** are drawn at right angles for illustration only. As shown in **FIG. 2**, the paths **11** and **12** would more likely intersect at an obtuse angle of 135° or thereabouts.

[0046] The defensive missile **10** includes a turreted gun **13** utilising one or more barrel assemblies of the type described, each loaded with grenade type projectiles engaged with rifling in the or each respective barrel for imparting a spin to the projectiles when fired so that each may be detonated at a selected distance from the defensive missile **10** which corresponds to a position coincident with the predicted flight path **12** of the incoming missile by utilising a spin count control for detonation.

[0047] The gun **13** may be turreted to a position more closely in-line with the flight path **11** as its fires so as to deposit a fragment column from exploding grenades along a significant distance of the incoming missile flight path, such as in the order of 300 feet of the predicted incoming flight path **12**. Alternatively the gun may remain fixed and the different angles required to position exploding grenades along the flight path may be produced by firing the grenades at different velocities so as to provide the required velocity vector resulting from the velocity of the defensive missile, the velocity of the defensive missile along the flight path **11** and the velocity of firing of the missile, to achieve the result as indicated diagrammatically by the vectors **15** and **16** and vectors therebetween.

[0048] The flight path of the defensive missile **11** is adapted to intercept the flight path **12** of the incoming missile to produce a direct hit at **18** with a view to destroying the incoming missile. However, if this does not occur, damage to the missile sustained through passing through the produced fragment column **20** may be sufficient to prevent it from reaching its destination or cause it to self destruct during transit towards the target zone. In the case of a ballistic missile, this may occur upon downward travel through the earth's atmosphere.

[0049] As shown in **FIG. 2**, the gun is fired on two separate occasions. Firstly to produce the fragment column **20** in the path **12** of the incoming missile towards the impact position **18** and secondly to the opposite side of the impact position so as to form a further fragment zone **21** in the path **12** of the incoming missile after passage beyond the predicted impact position **18**.

[0050] Referring to **FIG. 2**, it will be seen that the gun will fire to produce the trailing fragment zone **21** prior to being fired to produce the leading fragment zone **20**.

[0051] As an example given simply to illustrate the possible time spans involved, it is envisaged that a strategic missile travelling at 26,000 feet per second could be intercepted by a defensive missile travelling at 3,400 feet per second. For the first firing of the gun to produce the trailing fragment zone **21**, it is envisaged that the gun would be aimed to fire backward at 2,685 feet per second in the direction parallel to the incoming fight path **12** and with a vertical component of 610 feet per second. It is further envisaged that the firing duration would be 0.012 seconds during ???? projectiles would be fired and would finish 0.559 seconds and 1900 feet before the impact position **18** and would result in the production of a fragment column of about 300 foot long along the path **12** of the incoming missile beyond the impact position **18**.

[0052] The gun would then be rotated to fire from the other side of the anti-missile missile path **11** either by turreting of the gun **13** or rotation of the defensive missile **10** about its longitudinal axis. The gun would then fire forwards at 4,193 feet per second in a direction parallel to the path **12** and with a vertical component of 736 feet per second. Firing would start 0.456 seconds and 1,552 feet before the impact position **18**. The firing duration would be in the order of 0.012 seconds and again ???? projectiles would be fired so that the incoming strategic missile would enter the fragment column **20** approximately 400 feet before the impact position **18** and would pass through the column for the next 300 feet before impact.

[0053] This arrangement is possible by the use of a barrel assembly of the type described which may in the very short duration available in this instance in the 0.012 seconds of firing propel a significant number of projectiles which explode when in alignment with the incoming missile path **12**. Further as the barrel assembly is fully electronic controlled, the electronics can also include adjustable spin count timing means for adjusting the timing either in flight or prior to flight to achieve the desired result.

[0054] While a single turreting gun is preferred for minimising weight, a separate gun or guns may be utilised for firing to the respective sides. Additionally several guns may be arranged about the missile with pre set directions and charges and with a view to producing an array of debris about the anticipated impact zone with a view to increasing the effective size of defensive missile and the chance for achieving a collision of some form with the incoming missile.

[0055] **FIG. 3** shows an approximate calculation for determining firing times and angles of fire for particular scenarios. Where an incoming missile **31** travels along a trajectory that is defined by the x-axis **32** and is predicted to be impacted by an anti-missile missile **32** at **33**, the angle of fire of projectiles (not shown) from the barrel assemblies **34***a* and **34***b* may be calculated if the angle of attack of the anti-missile missile and the respective velocities are known.

[0056] e is shown as the distance along the trajectory of the incoming missile at which a projectile is desired to intercept the incoming missile. During the period of time it

takes the incoming missile to travel distance e, the anti-missile missile travels distance c:

$$c = e * \frac{\text{speed of anti-missile missile}}{\text{speed of incoming missile}}$$

θ is the angle of attack of the anti-missile missile relative to the direction of the incoming missile.

$$a = c * \cos(\theta - 180)$$

$$b = c * \sin(\theta - 180)$$

$$\alpha = \tan^{-1} \frac{(b)}{e + a}$$

[0057] β=α+θ−90 where β is the angle of the barrel assembly relative to the direction of the anti-missile missile (applicable to firing behind the predicted impact of the incoming missile and the anti-missile missile.

[0058] γ=180−β where γ is the angle of the barrel assembly relative to the direction of the anti-missile missile (applicable to firing in front of the predicted impact of the incoming missile and the anti-missile missile.

[0059] The time at interception of the projectile with the incoming missile (t_i).

$$t_i = \frac{e}{\text{Velocity of incoming missile}}.$$

[0060] The time of flight of the projectile (t_f).

$$t_f = \frac{d}{\text{Velocity of projectile}}.$$

[0061] The time of fire of the projectile (t_{fire}).

$$t_{fire} = t_i - t_f$$

[0062] Based upon the formula outlined above, the time and position at which the projectiles intercept the incoming missile may be determined and in Examples 1 to 8 hereinbelow there is shown the results of these calculations at various velocities of incoming missiles, anti-missile missiles and projectiles, angles of attack of anti-missile missiles and positions of interception of projectiles with incoming missiles. For convenience a few intermediate impact points have been selected but it will be understood that the present invention advantageously permits the firing of extremely high numbers of projectiles in the short period during which the firing may be effected in close proximity to the incoming missile. It will be appreciated that the closer the firing to the incoming missile the less the margin for error and the greater the likelihood of destroying or incapacitating the incoming missile.

[0063] It will of course be realised that the above has been given only by way of illustrative example of the invention and that all such modifications and variations thereto as would be apparent to persons skilled in the art are deemed to fall within the broad scope and ambit of the invention as is herein set forth.

EXAMPLE 1

[0064]

Incoming Missile	
Velocity	7924.8 ms^{-1}
Anti-missile Missile	
Velocity	1036.32 ms^{-1}
Angle of Attack	220 degrees
Projectile Launcher	
Muzzle velocity	426.72 ms^{-1}

	First Engagement				
	Initial Impact	Intermediate Impact	Intermediate Impact	Intermediate Impact	Final Impact
Intercept incoming missile relative to impact with anti-missile missile at (meters)	−152.4000	−129.5400	−106.6800	−83.8200	−60.9600
Barrel assembly angle relative to axis of anti-missile missile (degrees)	315.6309	315.6309	315.6309	315.6309	315.6309
Time of fire relative to impact of incoming missile with anti-missile missile at (seconds)	−0.4133	−0.3513	−0.2893	−0.2273	−0.1653
Time projectiles intercept incoming missile relative to impact of incoming missile with anti-missile missile at (seconds)	−0.0192	−0.0163	−0.0135	−0.0106	−0.0077

-continued

	Second Engagement
Intercept incoming missile relative to impact with anti-missile missile at (meters)	0.0000
Time of intercept of incoming missile by anti-missile missile at (seconds)	0.0000

	Third Engagement				
	Initial Impact	Intermediate Impact	Intermediate Impact	Intermediate Impact	Final Impact
Intercept incoming missile relative to impact with anti-missile missile at (meters)	152.4000	175.2600	198.1200	220.9800	243.8400
Barrel assembly angle relative to axis of anti-missile missile (degrees)	135.6309	135.6309	135.6309	135.6309	135.6309
Time of fire relative to impact of incoming missile with anti-missile missile at (seconds)	−0.3748	−0.4311	−0.4873	−0.5435	−0.5997
Time projectiles intercept incoming missile relative to impact of incoming missile with anti-missile missile at (seconds)	0.0192	0.0221	0.0250	0.0279	0.0308

EXAMPLE 2

[0065]

Incoming Missile	
Velocity	7924.8 ms^{-1}
Anti-missile Missile	
Velocity	1676.4 ms^{-1}
Angle of Attack	220 degrees
Projectile Launcher	
Muzzle velocity	426.72 ms^{-1}

	First Engagement				
	Initial Impact	Intermediate Impact	Intermediate Impact	Intermediate Impact	Final Impact
Intercept incoming missile relative to impact with anti-missile missile at (meters)	−152.4000	−129.5400	−106.6800	−83.8200	−60.9600
Barrel assembly angle relative to axis of anti-missile missile (degrees)	313.3260	313.3260	313.3260	313.3260	313.3260
Time of fire relative to impact of incoming missile with anti-missile missile at (seconds)	−0.4371	−0.3715	−0.3060	−0.2404	−0.1748
Time projectiles intercept incoming missile relative to impact of incoming missile with anti-missile missile at (seconds)	−0.0192	−0.0163	−0.0135	−0.0106	−0.0077

	Second Engagement
Intercept incoming missile relative to impact with anti-missile missile at (meters)	0.0000
Time of intercept of incoming missile by anti-missile missile at (seconds)	0.0000

-continued

	Third Engagement				
	Initial Impact	Intermediate Impact	Intermediate Impact	Intermediate Impact	Final Impact
Intercept incoming missile relative to impact with anti-missile missile at (meters)	152.4000	175.2600	198.1200	220.9800	243.8400
Barrel assembly angle relative to axis of anti-missile missile (degrees)	133.3260	133.3260	133.3260	133.3260	133.3260
Time of fire relative to impact of incoming missile with anti-missile missile at (seconds)	−0.3986	−0.4584	−0.5182	−0.5780	−0.6378
Time projectiles intercept incoming missile relative to impact of incoming missile with anti-missile missile at (seconds)	0.0192	0.0221	0.0250	0.0279	0.0308

EXAMPLE 3

[0066]

Incoming Missile	
Velocity	7924.8 ms^{-1}
Anti-missile Missile	
Velocity	1036.32 ms^{-1}
Angle of Attack	190 degrees
Projectile Launcher	
Muzzle velocity	426.72 ms^{-1}

	First Engagement				
	Initial Impact	Intermediate Impact	Intermediate Impact	Intermediate Impact	Final Impact
Intercept incoming missile relative to impact with anti-missile missile at (meters)	−152.4000	−129.5400	−106.6800	−83.8200	−60.9600
Barrel assembly angle relative to axis of anti-missile missile (degrees)	348.8475	348.8475	348.8475	348.8475	348.8475
Time of fire relative to impact of incoming missile with anti-missile missile at (seconds)	−0.4224	−0.3591	−0.2957	−0.2323	−0.1690
Time projectiles intercept incoming missile relative to impact of incoming missile with anti-missile missile at (seconds)	−0.0192	−0.0163	−0.0135	−0.0106	−0.0077

	Second Engagement
Intercept incoming missile relative to impact with anti-missile missile at (meters)	0.0000
Time of intercept of incoming missile by anti-missile missile at (seconds)	0.0000

	Third Engagement				
	Initial Impact	Intermediate Impact	Intermediate Impact	Intermediate Impact	Final Impact
Intercept incoming missile relative to impact with anti-missile missile at (meters)	152.4000	175.2600	198.1200	220.9800	243.8400
Barrel assembly angle relative to axis of anti-missile missile (degrees)	168.8475	168.8475	168.8475	168.8475	168.8475

-continued

Time of fire relative to impact of incoming missile with anti-missile missile at (seconds)	−0.3840	−0.4416	−0.4992	−0.5568	−0.6144
Time projectiles intercept incoming missile relative to impact of incoming missile with anti-missile missile at (seconds)	0.0192	0.0221	0.0250	0.0279	0.0308

EXAMPLE 4

[0067]

Incoming Missile	
Velocity	7924.8 ms^{-1}
Anti-missile Missile	
Velocity	1036.32 ms^{-1}
Angle of Attack	220 degrees
Projectile Launcher	
Muzzle velocity	853.44 ms^{-1}

	First Engagement				
	Initial Impact	Intermediate Impact	Intermediate Impact	Intermediate Impact	Final Impact
Intercept incoming missile relative to impact with anti-missile missile at (meters)	−152.4000	−129.5400	−106.6800	−83.8200	−60.9600
Barrel assembly angle relative to axis of anti-missile missile (degrees)	315.6309	315.6309	315.6309	315.6309	315.6309
Time of fire relative to impact of incoming missile with anti-missile missile at (seconds)	−0.2163	−0.1838	−0.1514	−0.1189	−0.0865
Time projectiles intercept incoming missile relative to impact of incoming missile with anti-missile missile at (seconds)	−0.0192	−0.0163	−0.0135	−0.0106	−0.0077

	Second Engagement
Intercept incoming missile relative to impact with anti-missile missile at (meters)	0.0000
Time of intercept of incoming missile by anti-missile missile at (seconds)	0.0000

	Third Engagement				
	Initial Impact	Intermediate Impact	Intermediate Impact	Intermediate Impact	Final Impact
Intercept incoming missile relative to impact with anti-missile missile at (meters)	152.4000	175.2600	198.1200	220.9800	243.8400
Barrel assembly angle relative to axis of anti-missile missile (degrees)	135.6309	135.6309	135.6309	135.6309	135.6309
Time of fire relative to impact of incoming missile with anti-missile missile at (seconds)	−0.1778	−0.2045	−0.2311	−0.2578	−0.2845
Time projectiles intercept incoming missile relative to impact of incoming missile with anti-missile missile at (seconds)	0.0192	0.0221	0.0250	0.0279	0.0308

EXAMPLE 5

[0068]

Incoming Missile	
Velocity	7924.8 ms^{-1}
Anti-missile Missile	
Velocity	1036.32 ms^{-1}
Angle of Attack	290 degrees
Projectile Launcher	
Muzzle velocity	426.72 ms^{-1}

	First Engagement				
	Initial Impact	Intermediate Impact	Intermediate Impact	Intermediate Impact	Final Impact
Intercept incoming missile relative to impact with anti-missile missile at (meters)	−152.4000	−129.5400	−106.6800	−83.8200	−60.9600
Barrel assembly angle relative to axis of anti-missile missile (degrees)	242.6699	242.6699	242.6699	242.6699	242.6699
Time of fire relative to impact of incoming missile with anti-missile missile at (seconds)	−0.3632	−0.3087	−0.2542	−0.1998	−0.1453
Time projectiles intercept incoming missile relative to impact of incoming missile with anti-missile missile at (seconds)	−0.0192	−0.0163	−0.0135	−0.0106	−0.0077

	Second Engagement
Intercept incoming missile relative to impact with anti-missile missile at (meters)	0.0000
Time of intercept of incoming missile by anti-missile missile at (seconds)	0.0000

	Third Engagement				
	Initial Impact	Intermediate Impact	Intermediate Impact	Intermediate Impact	Final Impact
Intercept incoming missile relative to impact with anti-missile missile at (meters)	152.4000	175.2600	198.1200	220.9800	243.8400
Barrel assembly angle relative to axis of anti-missile missile (degrees)	62.6699	62.6699	62.6699	62.6699	62.6699
Time of fire relative to impact of incoming missile with anti-missile missile at (seconds)	−0.3247	−0.3735	−0.4222	−0.4709	−0.5196
Time projectiles intercept incoming missile relative to impact of incoming missile with anti-missile missile at (seconds)	0.0192	0.0221	0.0250	0.0279	0.0308

EXAMPLE 6

[0069]

Incoming Missile	
Velocity	7924.8 ms^{-1}
Anti-missile Missile	
Velocity	1036.32 ms^{-1}
Angle of Attack	345 degrees
Projectile Launcher	
Muzzle velocity	426.72 ms^{-1}

	First Engagement				
	Initial Impact	Intermediate Impact	Intermediate Impact	Intermediate Impact	Final Impact
Intercept incoming missile relative to impact with anti-missile missile at (meters)	−152.4000	−129.5400	−106.6800	−83.8200	−60.9600
Barrel assembly angle relative to axis of anti-missile missile (degrees)	192.7815	192.7815	192.7815	192.7815	192.7815
Time of fire relative to impact of incoming missile with anti-missile missile at (seconds)	−0.3315	−0.2818	−0.2320	−0.1823	−0.1326
Time projectiles intercept incoming missile relative to impact of incoming missile with anti-missile missile at (seconds)	−0.0192	−0.0163	−0.0135	−0.0106	−0.0077

	Second Engagement
Intercept incoming missile relative to impact with anti-missile missile at (meters)	0.0000
Time of intercept of incoming missile by anti-missile missile at (seconds)	0.0000

	Third Engagement				
	Initial Impact	Intermediate Impact	Intermediate Impact	Intermediate Impact	Final Impact
Intercept incoming missile relative to impact with anti-missile missile at (meters)	152.4000	175.2600	198.1200	220.9800	243.8400
Barrel assembly angle relative to axis of anti-missile missile (degrees)	12.7815	12.7815	12.7815	12.7815	12.7815
Time of fire relative to impact of incoming missile with anti-missile missile at (seconds)	−0.2930	−0.3370	−0.3809	−0.4249	−0.4689
Time projectiles intercept incoming missile relative to impact of incoming missile with anti-missile missile at (seconds)	0.0192	0.0221	0.0250	0.0279	0.0308

EXAMPLE 7

[0070]

Incoming Missile	
Velocity	7924.8 ms^{-1}
Anti-missile Missile	
Velocity	1036.32 ms^{-1}
Angle of Attack	220 degrees
Projectile Launcher	
Muzzle velocity	426.72 ms^{-1}

	First Engagement				
	Initial Impact	Intermediate Impact	Intermediate Impact	Intermediate Impact	Final Impact
Intercept incoming missile relative to impact with anti-missile missile at (meters)	−152.4000	−129.5400	−106.6800	−83.8200	−60.9600
Barrel assembly angle relative to axis of anti-missile missile (degrees)	315.6309	315.6309	315.6309	315.6309	315.6309
Time of fire relative to impact of incoming missile with anti-missile missile at (seconds)	−0.4133	−0.3513	−0.2893	−0.2273	−0.1653
Time projectiles intercept incoming missile relative to impact of incoming missile with anti-missile missile at (seconds)	−0.0192	−0.0163	−0.0135	−0.0106	−0.0077

	Second Engagement
Intercept incoming missile relative to impact with anti-missile missile at (meters)	0.0000
Time of intercept of incoming missile by anti-missile missile at (seconds)	0.0000

	Third Engagement				
	Initial Impact	Intermediate Impact	Intermediate Impact	Intermediate Impact	Final Impact
Intercept incoming missile relative to impact with anti-missile missile at (meters)	67.2084	92.4215	117.6376	142.8537	168.0667
Barrel assembly angle relative to axis of anti-missile missile (degrees)	135.6309	135.6309	135.6309	135.6309	135.6309
Time of fire relative to impact of incoming missile with anti-missile missile at (seconds)	−0.1653	−0.2273	−0.2893	−0.3514	−0.4134
Time projectiles intercept incoming missile relative to impact of incoming missile with anti-missile missile at (seconds)	0.0085	0.0117	0.0148	0.0180	0.0212

EXAMPLE 8

[0071]

Incoming Missile	
Velocity	7924.8 ms^{-1}
Anti-missile Missile	
Velocity	1036.32 ms^{-1}
Angle of Attack	345 degrees
Projectile Launcher	
Muzzle velocity	426.72 ms^{-1}

	First Engagement				
	Initial Impact	Intermediate Impact	Intermediate Impact	Intermediate Impact	Final Impact
Intercept incoming missile relative to impact with anti-missile missile at (meters)	−152.4000	−129.5400	−106.6800	−83.8200	−60.9600
Barrel assembly angle relative to axis of anti-missile missile (degrees)	192.7815	192.7815	192.7815	192.7815	192.7815
Time of fire relative to impact of incoming missile with anti-missile missile at (seconds)	−0.3315	−0.2818	−0.2320	−0.1823	−0.1326
Time projectiles intercept incoming missile relative to impact of incoming missile with anti-missile missile at (seconds)	−0.0192	−0.0163	−0.0135	−0.0106	−0.0077

	Second Engagement
Intercept incoming missile relative to impact with anti-missile missile at (meters)	0.0000
Time of intercept of incoming missile by anti-missile missile at (seconds)	0.0000

	Third Engagement				
	Initial Impact	Intermediate Impact	Intermediate Impact	Intermediate Impact	Final Impact
Intercept incoming missile relative to impact with anti-missile missile at (meters)	68.9762	94.8538	120.7313	146.6088	172.4863
Barrel assembly angle relative to axis of anti-missile missile (degrees)	12.7815	12.7815	12.7815	12.7815	12.7815
Time of fire relative to impact of incoming missile with anti-missile missile at (seconds)	−0.1326	−0.1824	−0.2321	−0.2819	−0.3317
Time projectiles intercept incoming missile relative to impact of incoming missile with anti-missile missile at (seconds)	0.0087	0.0120	0.0152	0.0185	0.0218

1. An anti-missile missile including a missile configured to intercept an incoming missile wherein said anti-missile missile further includes at least one barrel assembly having a multiplicity of projectiles stacked axially within the at least one barrel assembly together with discrete selectively ignitable propellant charges for propelling the multiplicity of projectiles sequentially through the muzzle of the at least one barrel assembly.

2. An anti-missile missile according to claim 1 wherein the anti-missile missile includes a guidance system for tracking the path of the incoming missile and maintaining the anti-missile missile on a path to intercept the incoming missile.

3. An anti-missile missile according to claim 2 wherein the guidance system incorporates a path sensing means that is associated with an aiming mechanism for the at least one barrel assembly.

4. An anti-missile missile according to claim 1 wherein the at least one barrel assembly includs a barrel; a multiplicity of projectiles axially disposed within the barrel for operative sealing engagement with the bore of the barrel,

and discrete propellant charges for propelling respective projectiles sequentially through the muzzle of the barrel.

5. An anti-missile missile according to claim 1 wherein the projectile is selected from the group consisting of projectiles that are round, conventionally shaped or dart-like, optionally with fins off-set to generate a stabilising spin as the dart is propelled from a barrel.

6. An anti-missile missile according to claim 1 wherein the projectiles are propelled from the at least one barrel assembly by a propellant that is sequentially ignited by an electronic charge.

7. An anti-missile missile according to claim 1 wherein the at least one barrel assembly is arranged to deploy projectiles into the path of the incoming missile both before and after the predicted impact of the anti-missile missile and the incoming missile.

8. An anti-missile missile according to claim 1 wherein a single barrel assembly is arranged to deploy projectiles into path of the incoming missile both before and after the predicted impact of the anti-missile missile and the incoming missile.

9. An anti-missile missile according to claim 1 wherein the barrel assembly simultaneously fires projectiles in opposite directions so as to minimise any change of flight path of the anti-missile missile.

10. An anti-missile missile according to claim 1 wherein the projectile is a grenade-like projectile that is capable of detonating in the path of the incoming missile so as to create a column of fragments through which the incoming missile must pass.

11. An anti-missile missile according to claim 10 wherein the projectile uses spin count for gauging the distance/timing to the position at which it crosses the path of the incoming missile and detonates at that position.

12. An anti-missile missile according to claim 11 wherein multiple projectiles fired from the at least one barrel assembly have the spin count preset for each projectile and the time delay in the firing sequence provides the desired separation or intermingling of deployed fragments along the flight path of the incoming missile.

13. An anti-missile missile according to claim 10 wherein the timing mechanism may be adjustable in flight with input provided by incoming missile path sensor.

14. An anti-missile missile according to claim 1 wherein aiming corrections to the at least one barrel assembly may be effected by a rotation on mountings on the anti-missile missile about its axis and/or rotation of the missile axis.

15. A method of destroying or incapacitating an incoming missile comprising the steps of launching an anti-missile missile wherein said anti-missile missile includes a missile configured to intercept said incoming missile and wherein said anti-missile missile further includes at least one barrel assembly having a multiplicity of projectiles stacked axially within the at least one barrel assembly together with discrete selectively ignitable propellant charges for propelling the multiplicity of projectiles sequentially through the muzzle of the at least one barrel and sequentially firing said multiplicity of projectiles at said incoming missile.

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