

Oct. 8, 1963

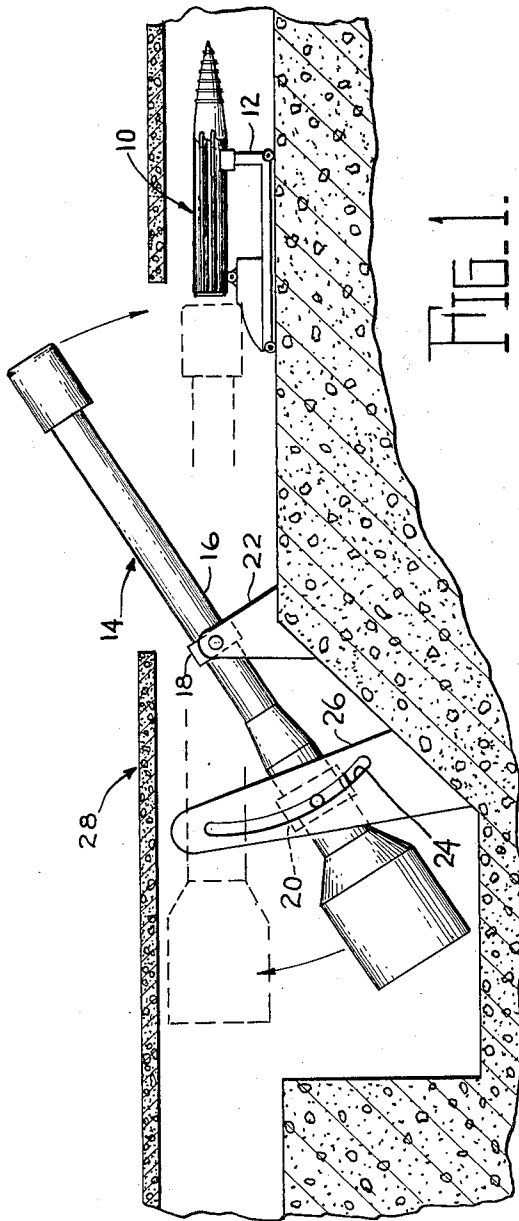
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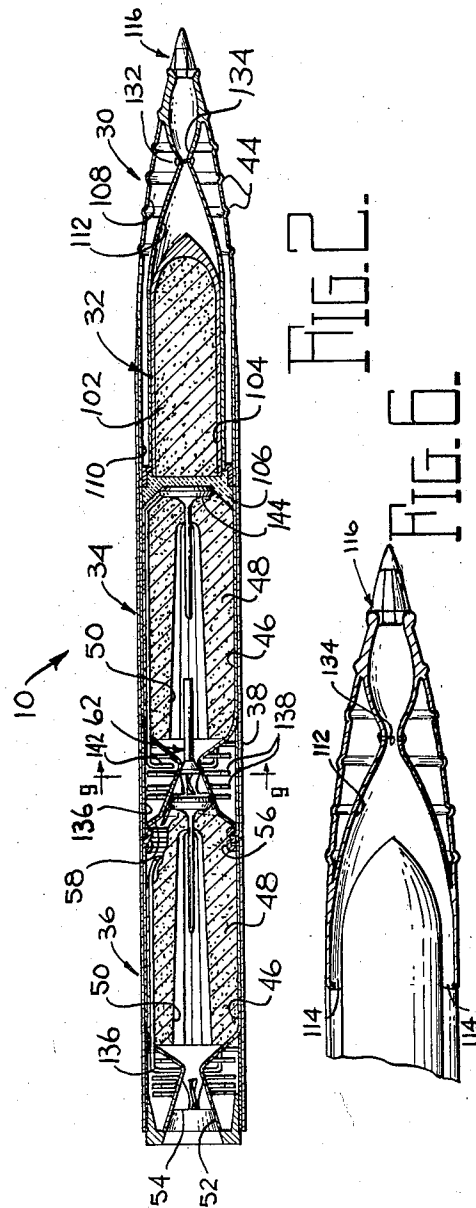
NOSE COOLING MEANS FOR MISSILES

Filed May 8, 1959

4 Sheets-Sheet 1



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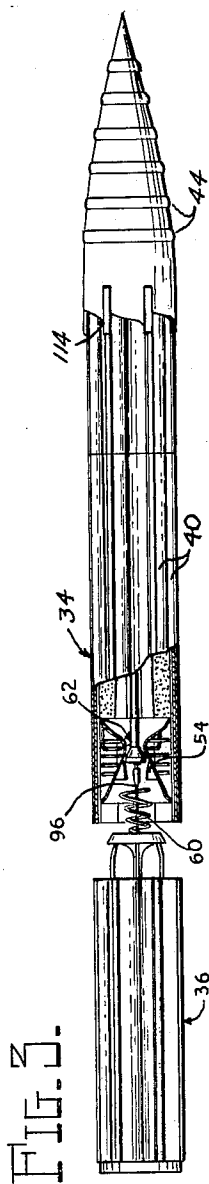
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NOSE COOLING MEANS FOR MISSILES

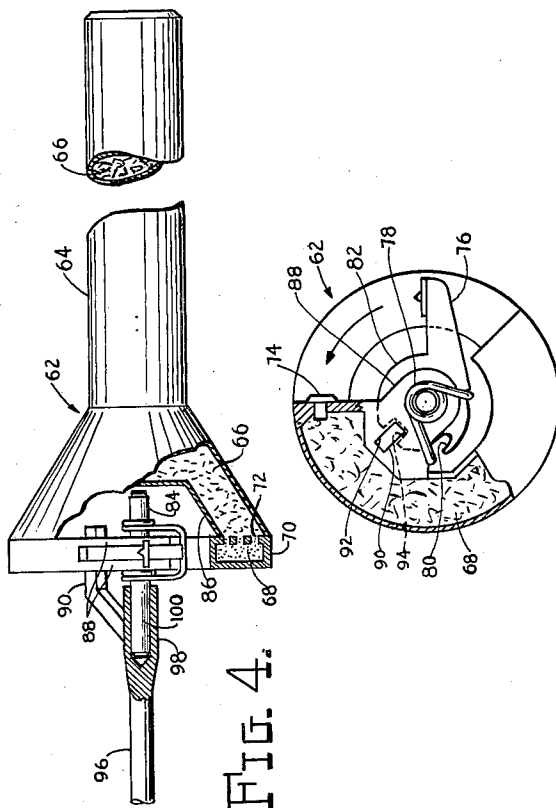
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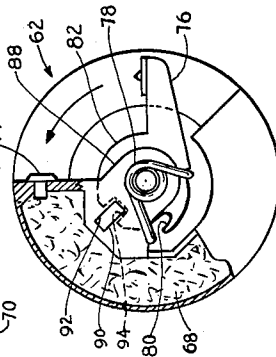


The diagrams show the construction of the character '日' (rì) in four steps:

- Step 1: A vertical line on the left and a horizontal line on the right, forming the basic structure.
- Step 2: The horizontal line is extended to the left, meeting the vertical line.
- Step 3: The horizontal line is extended further to the left, creating a longer horizontal stroke.
- Step 4: The final character '日' is completed, consisting of a vertical line on the left and a horizontal line on the right, with the horizontal line extended to the left.



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三

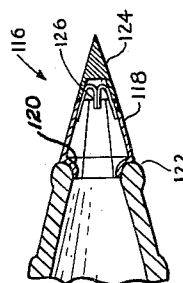
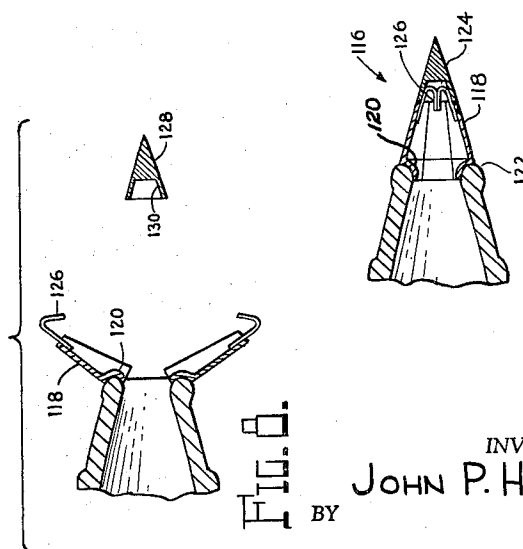


Fig. 2.

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3,106,162

NOSE COOLING MEANS FOR MISSILES

Filed May 8, 1959

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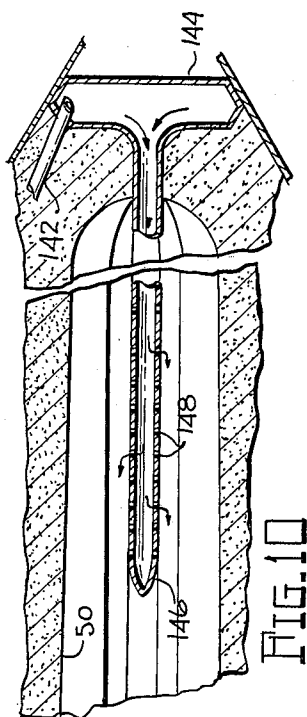


FIG. 10

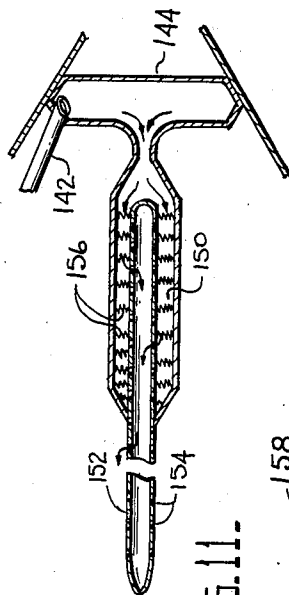


FIG. 11

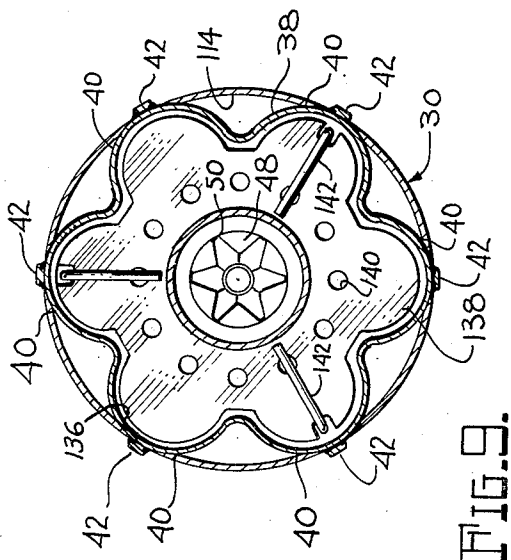


FIG. 9

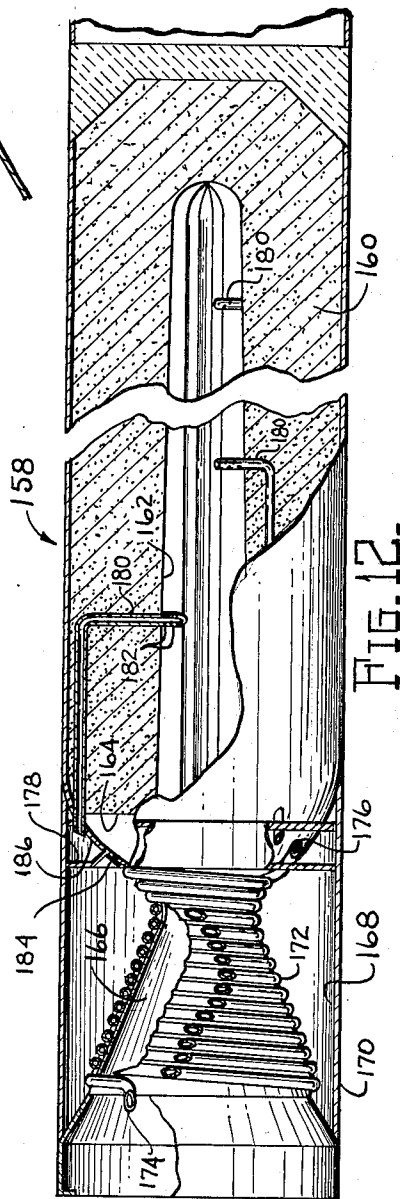


FIG. 12

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3,106,162

NOSE COOLING MEANS FOR MISSILES

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4 Sheets-Sheet 4

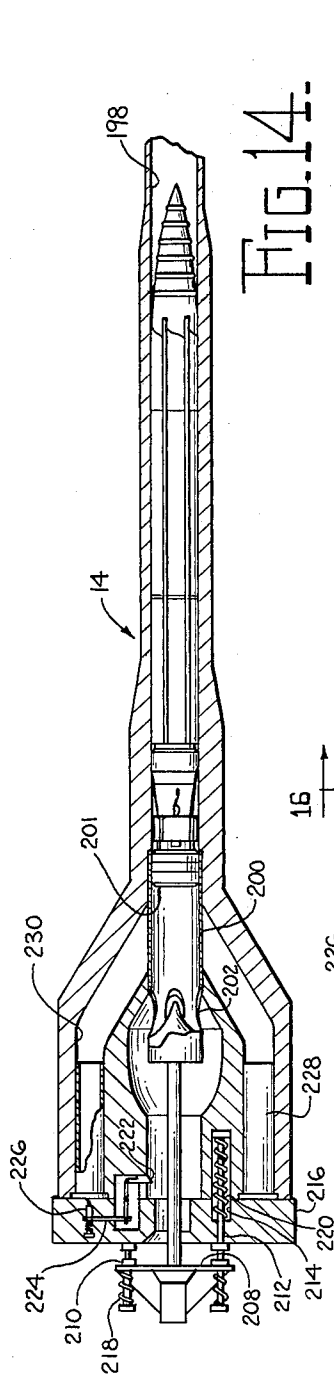


FIG. 14.

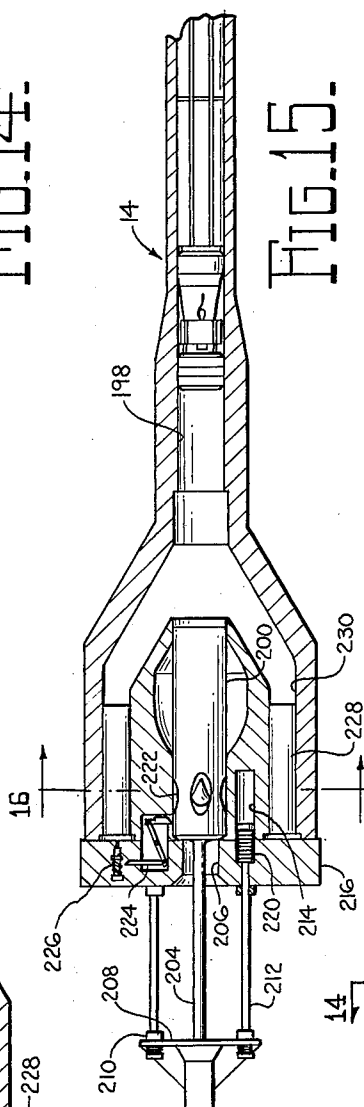


FIG. 15.

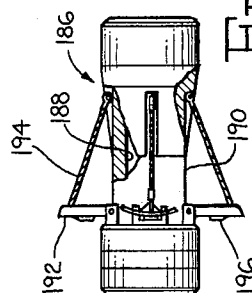
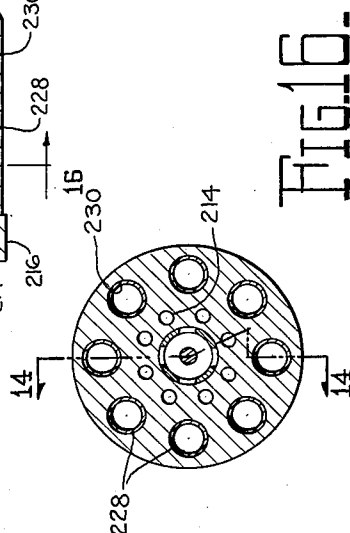


FIG. 13.



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NOSE COOLING MEANS FOR MISSILES

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2 Claims. (Cl. 102-92.5)

This invention relates to a system for transporting an object through the air from a point on the ground to another point, and more particularly to an improved powered projectile and projector for such a system.

A projectile and projector according to the present invention are primarily intended for use as a tactical weapon although they can also be used, for example, for rapidly transporting mail or other objects from one point on the ground to another point on the ground. However, the projectile and projector according to the invention can be employed for ground-to-air flights with the projectile leaving the gravitational pull of the earth.

The new projectile includes separate combustion sections in end-to-end relation, each of which is automatically detached from the remaining sections when its fuel is consumed, and upon detachment, automatically ignites the fuel in the next section. Combustion in each of the sections is augmented by a unique system employing a liquid such as water which is vaporized and superheated by heat transmitted from an exhaust nozzle of the combustion chamber. In addition, the liquid serves to cool the nozzle. Further, the new projectile has an improved nose cooling system with an ejectible nose tip and a coolant chamber which expands a coolant into a centrally located passage as the nose becomes heated.

The new projector for the projectile includes a rotating launching barrel which imparts initial rotation to the projectile to aid in maintaining the dynamic stability thereof. The projector also has a unique power system for imparting initial thrust to the projectile thus to reduce the amount of fuel the projectile must carry.

It is, therefore, a principal object of the invention to provide an air transporting system including an improved projectile and projector therefor having the features and advantages outlined above.

Other objects and advantages of the invention will be apparent from the following detailed description of preferred embodiments thereof, reference being made to the accompanying drawings, in which:

FIG. 1 is a view of a projectile and projector according to the invention, as positioned in a launching housing shown in cross section;

FIG. 2 is an enlarged longitudinal cross-sectional view of the projectile shown in FIG. 1;

FIG. 3 is a view, with parts broken away, of the projectile shown in FIGS. 1 and 2 but with a combustion section of the projectile shown detached from the remaining portion of the projectile;

FIG. 4 is a fragmentary side view with parts broken away and parts in cross section of an ignitor employed in one or more of the combustion sections of the projectile;

FIG. 5 is an end view of the ignitor shown in FIG. 4, with parts broken away and parts in cross section;

FIG. 6 is a fragmentary view in cross section, similar to FIG. 2, but taken through a central, longitudinal plane lying at an angle of 30° to the vertical;

FIG. 7 is an enlarged, fragmentary view in longitudinal cross section of the tip of the nose of the projectile;

FIG. 8 is a view in longitudinal cross section similar to FIG. 7 but showing the tip of the nose section partially disassembled;

FIG. 9 is an enlarged view in cross section taken along the line 9-9 of FIG. 2;

2

FIG. 10 is an enlarged, detailed view in cross section of a portion of a fuel augmenting system for a combustion section of the projectile;

FIG. 11 is an enlarged detailed view in cross section similar to FIG. 10, but showing a portion of a modified fuel augmenting system for a combustion section of the projectile;

FIG. 12 is an enlarged, fragmentary view, with parts broken away and parts in cross section of another modified fuel augmenting system for a combustion section;

FIG. 13 is a side view with parts broken away and parts in cross section of an accelerator employed behind the projectile to impart initial thrust thereto;

FIG. 14 is a fragmentary view in vertical longitudinal cross section of the projector shown in FIG. 1, when ready for firing;

FIG. 15 is a fragmentary view in vertical longitudinal cross section of a portion of the projector shown in FIGS. 1 and 14, just after firing; and

FIG. 16 is a view in lateral cross section taken along the lines 16-16 of FIG. 15.

Referring to FIG. 1, a projectile 10 according to the invention is shown on a cart 12 ready for loading into a projector 14, when the latter is moved to a horizontal position as indicated by the dotted lines. A barrel 16 of the projector is mounted for rotation in circumferentially extending bearings 18 and 20, the former of which is pivotally mounted in spaced forward supports 22 and the latter of which is slidably mounted and guided in a slot 24 of spaced rear supports 26. The projector 14 can be raised to an angle of 40° to 50° to enable the projectile 10 to reach the height or horizontal distance desired. The projectile, the projector, and its mountings are located in a reinforced concrete housing indicated generally by the numeral 28.

The projectile 10, shown in cross section in FIG. 2, includes a nose section 30, an object-carrying or war-head section 32, a first combustion section 34, and a second combustion section 36. It is to be understood that more than two combustion sections can be employed if desired because the number is limited only by the maximum length permissible for the projectile.

A main body 38 of the projectile 10 is convoluted to form six bourrelets 40 (see FIG. 9), each bourrelet having at its apex a longitudinal skid 42 of a material exhibiting a high degree of lubricity, such as "Teflon," to reduce friction between the body 38 and the bore of the projector 14. As the missile moves forwardly and rotates, due to the motion imparted by the rotation of the barrel 16, the bourrelets 40 produce areas of cavitation or turbulence and thereby reduce skin friction between the body 38 and the air. The shape of the body 38 also adds considerable strength to the projectile and enables it to withstand higher column loads imposed by the tremendous thrust and acceleration encountered upon firing the projectile 10.

The combustion sections 34 and 36 each include a combustion chamber 46 containing a solid fuel or propellant charge 48. This charge is formed with a central combustion passage 50 which extends longitudinally of the charge 48 and is designed with a cross section in the shape of a six-pointed star (FIG. 9) which establishes a large surface area. Burning of the fuel occurs in a direction laterally to the body 38 along the entire passage 50, and the large surface area enables a maximum amount of fuel to burn simultaneously, thereby to obtain maximum thrust. Combustion products escape at high velocity through an exhaust nozzle 52 generally in the shape of a venturi tube to establish smooth flow and maximum velocity. The nozzle 52 contains vanes 54 placed at a small angle to the path of discharge of the combustion gases to cause the projectile 10 to continue rotation in flight due to

the reaction to the force imparted upon the vanes by the high velocity products of combustion.

When the charge 48 in the second combustion section 36 is substantially consumed and the burning surface is close to the shell of the chamber 46, a connecting ring 56 of a comparatively low melting alloy melts or is consumed when subjected to the highly elevated temperatures of combustion. The destruction of the connecting ring 56 enables separation of the shell of the combustion chamber 46 of the second section 36, and a nozzle extension 58 thereof, from the first combustion section 34. Separation of the combustion sections of the projectile 10 is aided by a spring 60 (FIG. 3) maintained in a compressed state between the first combustion section 34 and the second combustion section 36 when they are connected by the ring 56. Thus, the second combustion section 36 is discarded upon consumption of the charge 48 therein, thereby to reduce the overall weight of the projectile 10.

The fuel charge 48 in the first combustion section 34, which charge is identical to that in the second combustion section 36, is ignited upon separation of the second combustion section 36 by means of an ignitor 62, a preferred form of which is shown in detail in FIGS. 4 and 5. The ignitor 62 includes a casing 64 which extends into the passage 50 of the charge 48 and contains an igniting charge 66. The igniting charge 66 is ignited by a priming charge 68 in an arcuate housing 70, which priming charge, when burning emits flame or products of combustion through ports 72 and ignites the charge 66 which destroys the casing 64 and ignites the main charge 48. The priming charge 68 is fired by a percussion cap 74 when struck by a hammer 76 maintained under pressure by a spring 78, one end of which is anchored against the housing 70 and the other end of which can be engaged in a notch 80 of a hub portion 82 of the hammer 76. However, the spring 78 is preferably kept out of the notch 80 until the projectile 10 is ready to be loaded into the projector 14, to prevent accidental firing. The hub portion 82 is rotatably mounted on an axle 84 located in a recess 86 forming part of the casing 64. The spring 78 is also coiled around part of the axle 84 which is rotatably mounted in ears 88 extending inwardly from the housing 70. A sear 90 projects through square holes 92 in the ears 88 and also through a recess 94 in the hub portion 82 of the hammer 76. The sear 90 thereby prevents rotation of the hammer 76 when the one end of the spring 78 is engaged in the notch 80 of the hub portion 82. The sear 90 is attached to a connecting rod 96 which has an enlarged head 98 slidably held on an extension 100 of the axle 84. The other end of the rod 96 is attached to a portion of the second combustion section 36 and is withdrawn from the axle extension 100 when the second combustion section 36 is separated. As the rod 96 is separated, it withdraws the sear 90 from the square holes 92 and the recess 94, thus enabling the spring 78 to swing rapidly the hammer 76 against the percussion cap 74. This causes the cap 74 to explode, thus igniting the priming charge 68, then the igniting charge 66, and finally the propellant charge 48. The propellant charge 48 in the first combustion section 34 is ignited almost instantaneously as the second combustion section 36 is separated therefrom.

All parts of the ignitor 62 are made of combustible or low melting materials and are destroyed during combustion of the charge 48, with the exception of the percussion cap 74 and the drive spring 78 which are blown through the exhaust nozzle 52.

The warhead section 32 includes a suitable explosive charge 102 in a casing 104 adjacent a heavy thrust plate 106 separating the explosive charge 102 from the first combustion section 34. The plate 106 preferably comprises a high temperature insulating material such as fibrous potassium titanate to protect the explosive 102 from the heat of the combustion section 34. It is to be understood that the explosive charge 102 can be replaced

by mail or other objects which are to be transported from one point on the ground to another point.

The nose and warhead sections are kept cool by the evaporation of cooling fluid, which can be Freon 12 or helium, for example, maintained under pressure in an annular coolant tank 108 with tank extensions 110 extending toward the rear of the projectile 10 around the explosive charge casing 104. The extensions 110 are contained only within the six bourrelets 40. A generally venturi-shaped central cooling passage 112 extends longitudinally of the nose section 30 and through the center of the annular tank 108 to receive coolant released from the tank 108 and exhaust it through outlet passages 114 (FIGS. 6 and 9) defined by the valleys and the cylindrical casing of the nose section.

The heat developed in the nose and warhead sections can be carried away by air passing through the passage 114. However, the entrance or inlet end of the passage 114 is normally closed off by a nose tip 116 (FIGS. 7 and 8) which includes a plurality of segments 118 having hook-shaped portions 120 at their larger ends extending around and engaging a leading edge 122 at the inlet end of the cooling passage 112. Generally U-shaped spring wires 124 are affixed to the smaller ends of the segments 118 and have inner ends 126 meeting at the axis of the tip 116. The spring wires 124 are under compression, when the segments 118 are in assembled relationship to form a truncated conical wall portion of the tip 116, and urge the segments 118 outwardly away from one another. However, the segments 118 are prevented from separating by a cone 128 of a relatively low melting material which has a recess 130 into which portions of the spring wires 124 extend, with the base of the cone 128 abutting the smaller ends of the segments 118.

During the initial portion of the path of the projectile 10 upwardly through the atmosphere, air friction heats the nose section 30 but not to a temperature sufficiently high to melt the cone 128. However, the elevated temperature does cause an increase in pressure of the coolant and forces open pressure relief escape valves 132 (FIGS. 2 and 6) located at a throat 134 of the cooling passage 112. The refrigerant thereby is expanded into the passage 112, which is at a negative pressure due to the Bernoulli effect of the air rushing past the outlet ends of the outlet passages 114, and the expanded refrigerant reduces the temperature of the nose section 30.

The valves 132 close as the projectile 10 travels through less dense air in the upper portion of its flight where skin friction is reduced and the nose section 30 cools. However, when the projectile 10 begins re-entry into the earth's more dense atmosphere, friction between the projectile 10 and the air establishes very high temperatures at the nose section 30. As the temperature builds up, the cone 128 melts, thereby releasing the springs 124 which force the segments 118 apart as shown in FIG. 8. The segments are carried away, leaving the entrance end of the passage 112 open and enabling air to pass there-through and out the outlet passages 114. This air carries away heat and develops low pressure at the throat 134 which, along with the high temperature of the nose section 30 resulting in high pressure in the tanks 108, causes the escape valves 132 to open fully and the flow of coolant into the passage 112 and the outlet passages 114 to be greatly accelerated. The explosive charge 102 in the casing 104 receives maximum protection from heat by this arrangement.

The principal source of fuel and power for operation of the projectile 10 is the solid fuel charge 48 in the combustion sections 34 and 36. However, an augmenting fuel system can be incorporated, if desired. Accordingly, a fuel tank 136 (FIGS. 2 and 9) is defined between each of the exhaust nozzles 52 and the projectile casing 38, which tank contains liquified gases, compressed gases, or water, as additional sources of fuel. For example, the tanks 136 can contain a combination of water and alcohol

5

which, besides serving as fuel, serves to cool the exhaust nozzles 52. To increase heat transfer from the nozzle 52 to the contents of the fuel tank 136, a plurality of heat transfer discs or fins 138 are attached to the nozzles and extend radially therefrom. The discs 138 contain ports 140 (FIG. 9) through which the liquid in the tanks 136 can circulate. The heat vaporizes the liquid which is forced inwardly around the nozzle 52 because the rotation of the projectile 10 forces the heavier liquid to the outer periphery of the tank 136. The vapor is thereby forced into inlet lines 142, which have inlets at a point near the central portion of the tank 136 and which extend through the combustion chamber 46, near the periphery thereof, to a supply header 144 (FIG. 10) located at the forward end of the main fuel chamber 46. The header 144 is connected to a manifold pipe 146 which extends axially through a portion of the charge 48 and has a plurality of supply ports 148 through which the vapor is emitted. This vapor thereby burns with the fuel charge 48 and serves the dual purposes of both cooling the nozzle 52 and augmenting the fuel supply.

A portion of a modified fuel augmenting system is shown in FIG. 11. In this case, the vapor, particularly superheated steam, is supplied through the line 142 to the supply header 144 and passes into a chamber 150 before passing into a manifold 152 and out ports 154. The chamber 150 contains iron grids 156 which can also be in the form of wool or mats. The iron, which is heated to a high temperature by combustion of the solid fuel charge 48, reacts with the superheated steam to form hydrogen and oxygen. The hydrogen is then burned as an auxiliary to the solid fuel and the oxygen supports and increases the intensity of combustion.

A modified fuel augmenting system, shown in FIG. 12, includes a modified combustion section 158 which can be substituted for either or both of the previously described combustion sections 34 and 36. The section 158 has a solid fuel charge 160 with a combustion space 162 formed therein, and, in addition, a second combustion space 164 formed near a nozzle 166. A fuel tank 168 to hold augmenting fuel is formed between the nozzle 166 and a casing 170, and contains a suitable fuel, as discussed above. Around the nozzle 166 is a coil 172 of tubing having an inlet 174 near the rear, central portion of the tank 168 and an outlet 176 in a supply header 178 separate from the tank 168. Three discharge lines 180 extend from the header 178 through portions of the fuel charge 160 and into spaced portions of the combustion space 162. The tips of the lines 180 contain ports 182 through which vapor is emitted into the combustion space 162. The inlet 174 of the coil 172 is normally closed by a fuse plug 184 and is opened when the fuse plug melts so that fuel from the tank 168 is forced through the inlet 174. The pressure in the second combustion space 164 then forces the fuel through the coil 172 and the outlet 176 into the supply header 178 from which it flows through the lines 180 and out the ports 182. The fuel is vaporized as it passes through the coil 172 and is emitted into the combustion space 162 as a vapor. The fuel again serves the double function of cooling the nozzle 166 and acting as an auxiliary fuel supply for the charge 160.

Part of the initial thrust of the powered projectile 10 can be supplied by an accelerator 186 shown in FIG. 13. The accelerator includes a combustible propellant in a chamber 188, the products of combustion of which are exhausted through exhaust ports (not shown) at the rear of the accelerator 186. The front of the accelerator abuts the rear of the projectile 10 when placed in the projector 14 and the rear of the accelerator 186 is designed to closely fit in the projectile to prevent escape of propelling gases past the projectile 10 as would otherwise occur because of the convoluted shape of the projectile body. An intermediate portion 190 of the accelerator 186 is of smaller diameter than the ends to accommodate four air

6

brakes 192 which are pivotally attached to the intermediate portion 190 and are urged into closed position against the intermediate portion by suitable springs associated with the pivot points of the air brakes 192. Opening of the air brakes 192 is limited by cables 194 which prevent the brakes 192 from being torn off by the air. The brakes 192 are maintained in a closed position adjacent the intermediate portion 190 when placed in the projector 114, and at this time, the cables 194 are coiled beneath the brakes. The brakes 192 have suitable runners 196 of Teflon or the like to enable them to slide freely in the bore of the projector 14. When the charge in the chamber 188 is ignited, the thrust thereby created maintains the accelerator 186 in abutting relationship with the projectile 10 and this relationship remains until the projectile and accelerator have traveled some distance from the projector 14 and substantial initial velocity has been imparted to the projectile. At this time, the charge in the chamber 188 is of such a quantity as to be substantially consumed and, as the forward motion of the projectile 10 increases, the velocity of the air passing the accelerator 186 becomes sufficient to overcome the force of the springs holding the brakes 192 against the intermediate portion 190. Consequently, the brakes 192 open and produce considerable drag on the accelerator, thereby slowing it down and separating it from the projectile 10. The projectile then continues in flight under its own power of the fuel in the combustion sections 34 and 36.

Reference will be made to FIGS. 14-16, for a description of the projector 14. The projectile 10 and the accelerator 186 are placed in a bore 198 of the projector 14 with a rear portion of the accelerator pushed into an accelerator sleeve 200 until it abuts stops 201 therein. The sleeve has four elongated holes 202 near the rear through which thrust gases from the accelerator 186 pass. The holes 202, by permitting the exhausting of a portion of the thrust gases from the accelerator 186, reduce the pressure built up in the breech block 216 and enable the projectile 10 to start more slow and thereby to minimize acceleration loads. A longitudinally extending rod 204 is affixed to the rear wall of the sleeve 200 and extends through an exhaust outlet 206 to a buffer plate 208 having sleeve bearings 210 through which stop rods 212 extend into cylindrical chambers 214 in a breech block 216. The stop rods 212 have buffer springs 218 and 220 at the outer ends thereof, the latter being located in the cylindrical chambers 214.

After the projector 14 is rotated and has reached a predetermined rotational speed, the accelerator 186 is fired and the exhaust gases thereof pass through the holes 202 in the sleeve 200 which is forced rearwardly when the exhaust gases reach a predetermined volume. The sleeve 200 thereupon strikes firing cams 222 which, through levers 224, release spring loaded firing pins 226 which fire eight driving charges 228 (FIG. 16) located in breech chambers 230. The force of the driving charges imparts additional acceleration to the projectile 10 and the accelerator 186 and thus extends the range of the projectile 10 for a given amount of fuel in the projectile.

To review the overall operation of the projectile and the projector, the barrel 16 of the projector 14 is swung to a horizontal position with the muzzle resting on the cart 12, at which time the accelerator 186 and the projectile 10 are muzzle loaded and pushed into the bore 198 until the rear portion of the accelerator 186 abuts the stops 201 in the sleeve 200. The barrel 16 is then swung to the desired firing angle and, when ready for firing, is rotated by suitable means in order to impart initial rotation to the projectile 10. This eliminates the need for rifling in the bore 198 and thus eliminates a large amount of energy usually expended when a projectile engages rifling. Thus, the greatest amount of energy is available to propel the projectile in its forward motion. The accelerator 186 is then fired with the initial thrust gases

thereby produced exhausting through the holes 202 and the exhaust outlet 206. As the thrust gases from the accelerator increase in volume, the sleeve 200 is pushed rearwardly thereby closing off the exhaust holes 202 and firing the driving charges 228. By the time the driving charges 228 are fired, the accelerator 186 and the projectile 10 are already moving forwardly as shown in FIG. 15. The driving charges impart considerable additional initial thrust to the projectile 10 and the accelerator 186 which, when out of the bore 198 and traveling at a predetermined rate of speed, separates from the projectile 10 by the opening of the spring-loaded drag brakes 192.

The solid fuel 48 in the combustion chamber 36 is then ignited and imparts continued forward movement to the projectile 10 and continued rotation thereof due to the exhausts gases striking the guide vanes 54. Upon substantial completion of combustion of the fuel 48 in the combustion chamber 36, the connecting ring 56 is destroyed which, with the aid of the spring 60, enables the combustion section 36 to fall away from the first combustion section 34. The fuel charge in the latter is then ignited by the igniting assembly 62 and burning continues to propel and rotate the remaining portion of the projectile 10 including the warhead 32. A portion of the heat from the combustion gases passing through the exhaust nozzles 52 vaporizes liquid in the tank 136, and forces it into the combustion chambers 146 where it serves to augment the fuel supply.

During upward flight, heat generated by air friction expands the coolant in the annular chamber 108 until the pressure relief valves 132 open, thus enabling a portion of the coolant to expand into the venturi passage 112 and escape through the outlet passages 114 to cool the nose section 30 and the warhead section 32. Upon re-entry of the projectile 10 into more dense atmosphere, the tremendous heat generated causes the elements of the nose tip 116 to disband and disburse, thus enabling air to flow through the passage 112 and expand into the outlet passages 114. The remaining coolant in the chamber 108 also is exhausted through the valves 132 and further aids in cooling the warhead section 32.

Various modifications of the invention will suggest themselves to those skilled in the art and it is to be understood that such modifications can be made without departing from the scope of the invention as defined in the appended claims.

I claim:

1. In a projectile having means forming a nose section,

and means attached to the rear of said nose section for carrying an object to be transported, the improvement comprising a coolant tank in said nose section, means forming a generally venturi-shaped passage through said tank having an inlet at the tip of the nose section, and a plurality of outlets opening at an outer surface of the nose-forming means of the projectile near the rearward end of the coolant tank, said passage-forming means having a plurality of ports connecting said coolant tank with a throat portion of said venturi-shaped passage, a pressure relief valve in each of said ports, said pressure relief valve opening at a predetermined pressure to enable coolant from said tank to escape into said venturi passage when the nose section has reached a predetermined temperature causing pressure of the coolant in said tank to reach a predetermined value.

2. The combination according to claim 1 and means covering the inlet end of said venturi-shaped passage, said covering means being a nose tip of generally conical shape having a plurality of arcuate segments forming a truncated conical portion of said tip when said segments are assembled, means attached to said segments for urging them outwardly away one from another when in assembled relationship, and a cone of relatively low melting material engaging at least a part of said segments to hold them in their assembled relationship.

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