June 25, 1946. C. A. WHITSETT 2,402,716

ANTIAIRCRAFT SHELL

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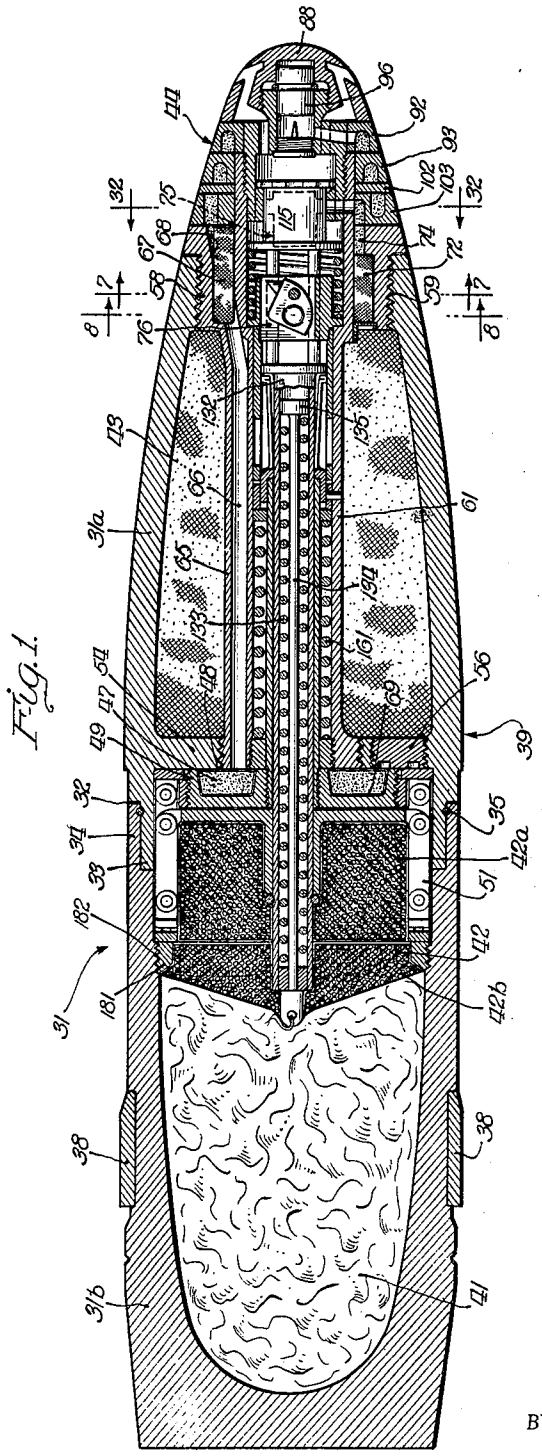


Fig. 1.

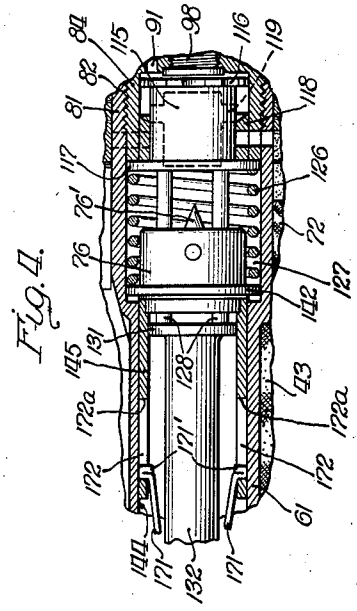


Fig. 4.

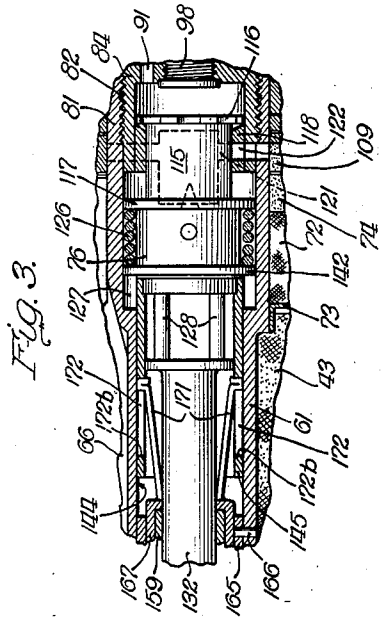


Fig. 3.

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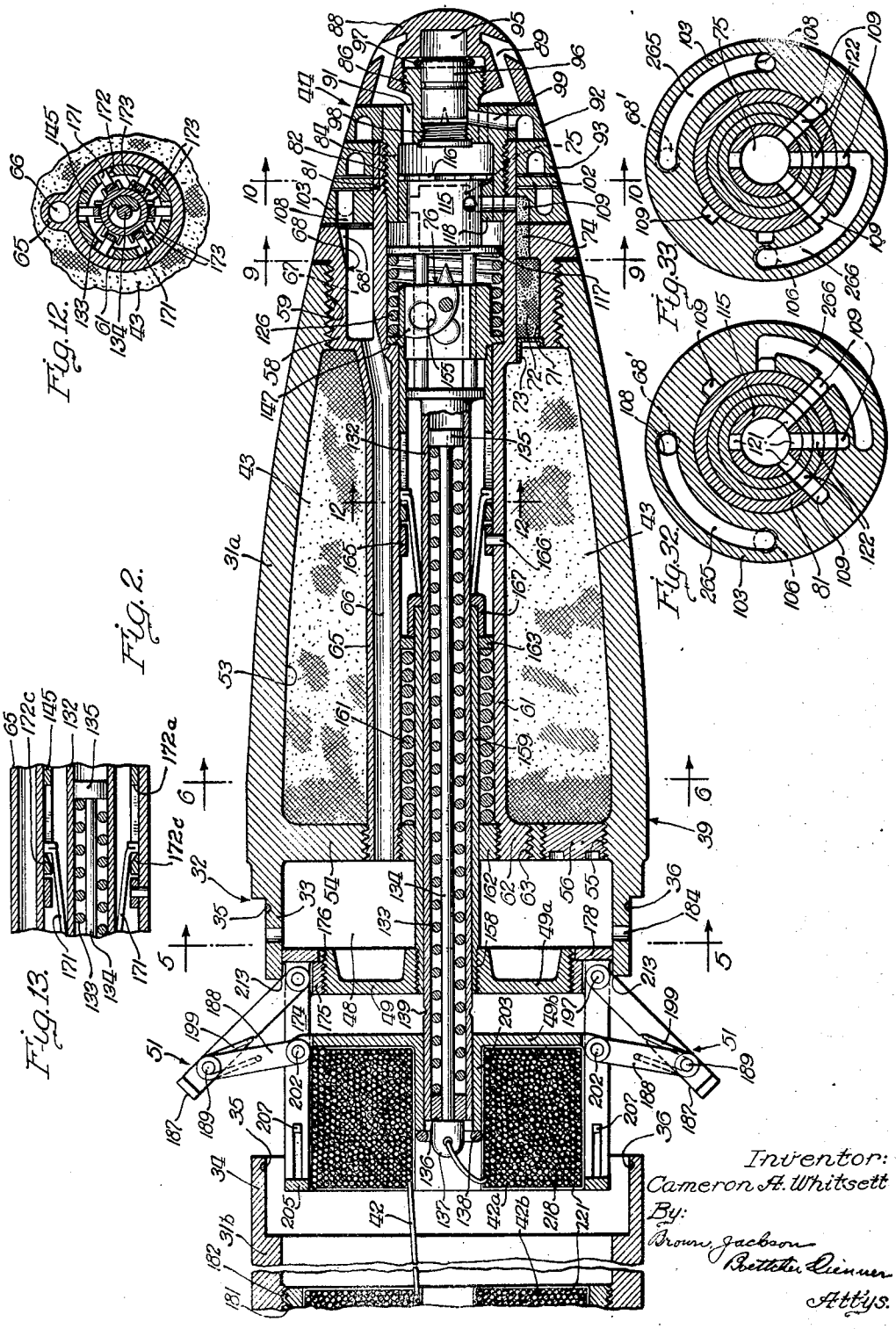


Fig. 12.

Fig. 33

Fig. 32.

Fig. 2.

Fig. 13.

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Fig. 5.

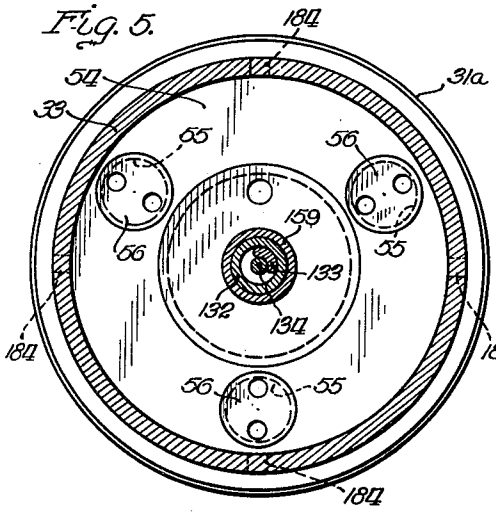


Fig. 6.

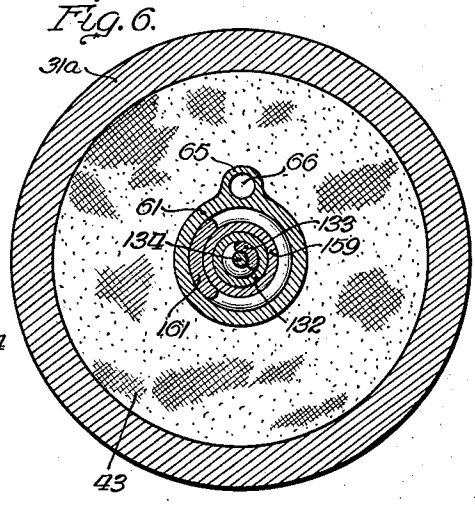


Fig. 7.

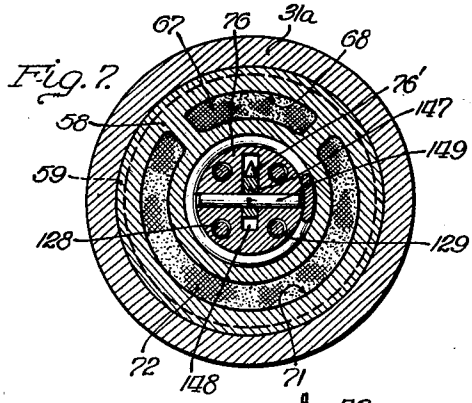


Fig. 8.

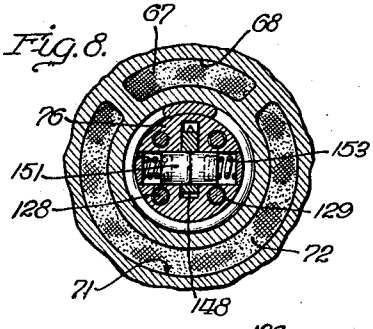


Fig. 9.

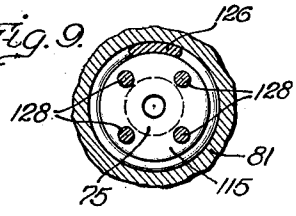


Fig. 11.

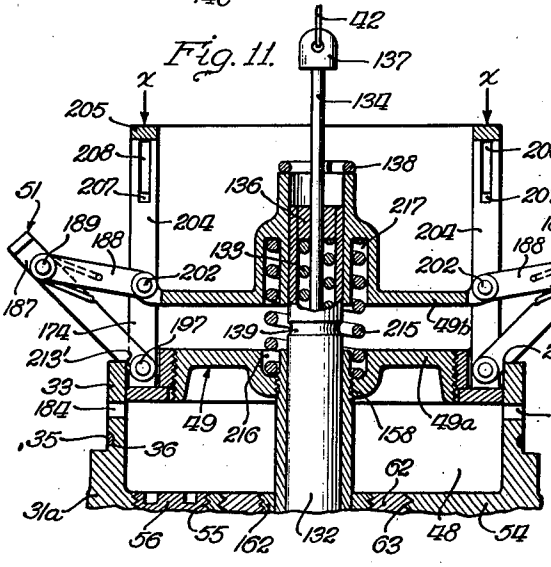
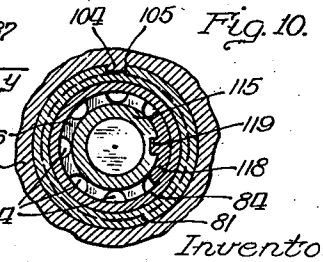


Fig. 10.



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Fig. 14.

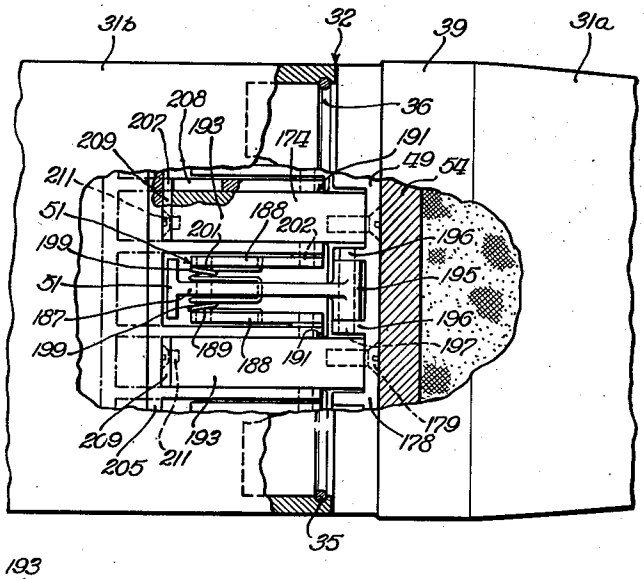


Fig. 15.

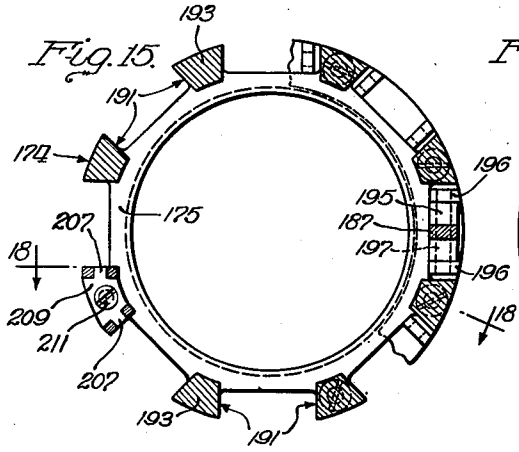


Fig. 16.

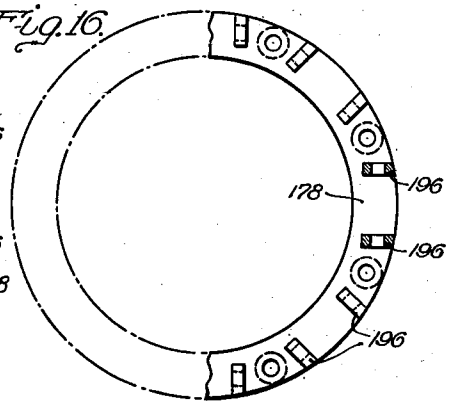


Fig. 17.

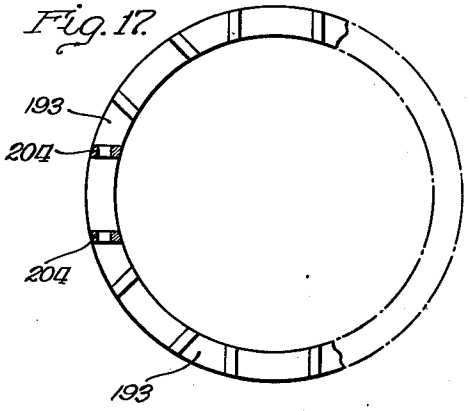
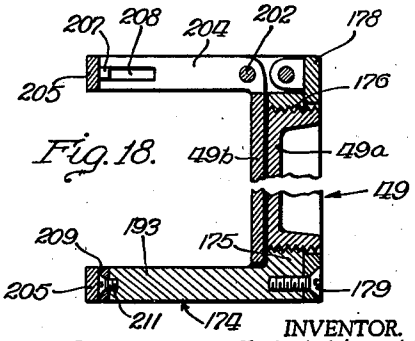


Fig. 18.



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Fig. 19.

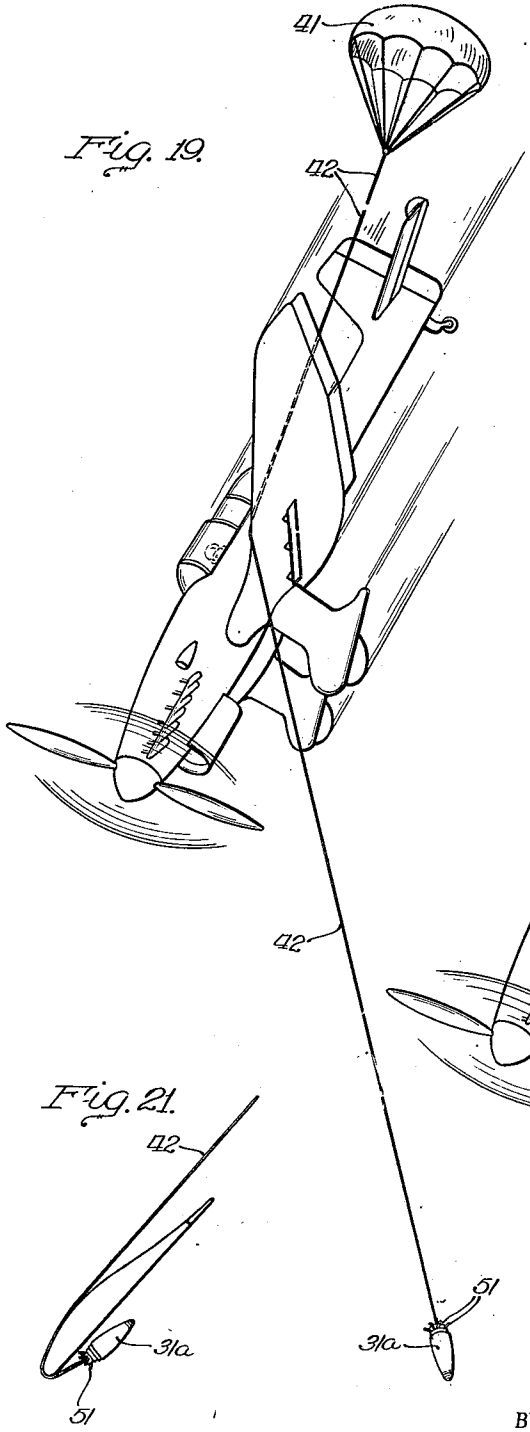


Fig. 20.

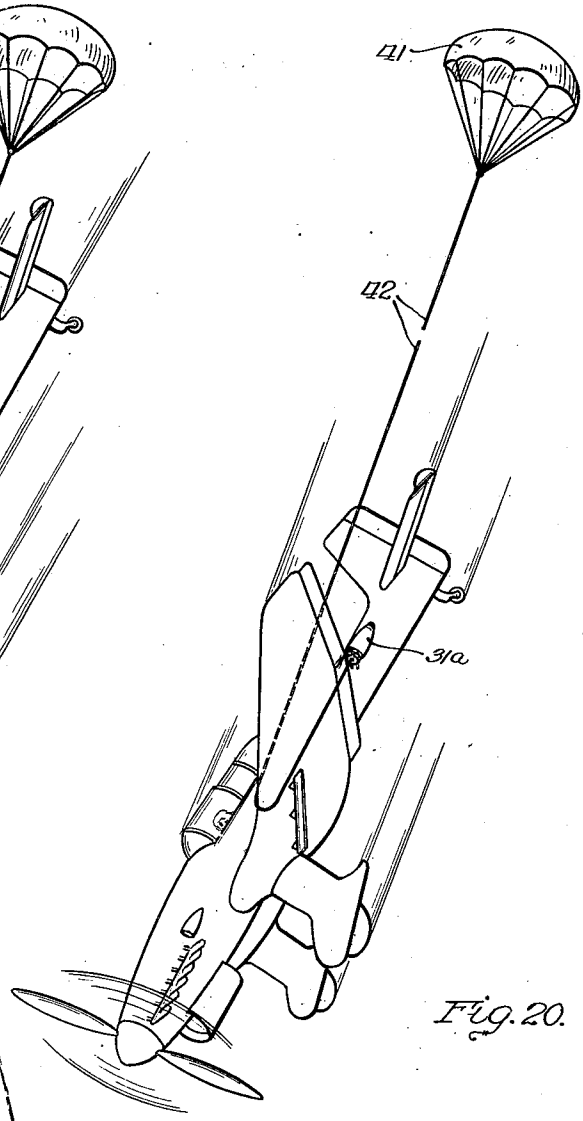


Fig. 21.

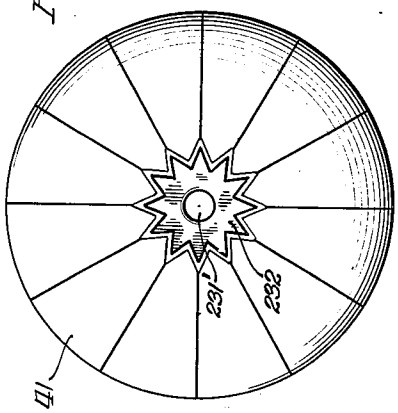
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Fig. 21.



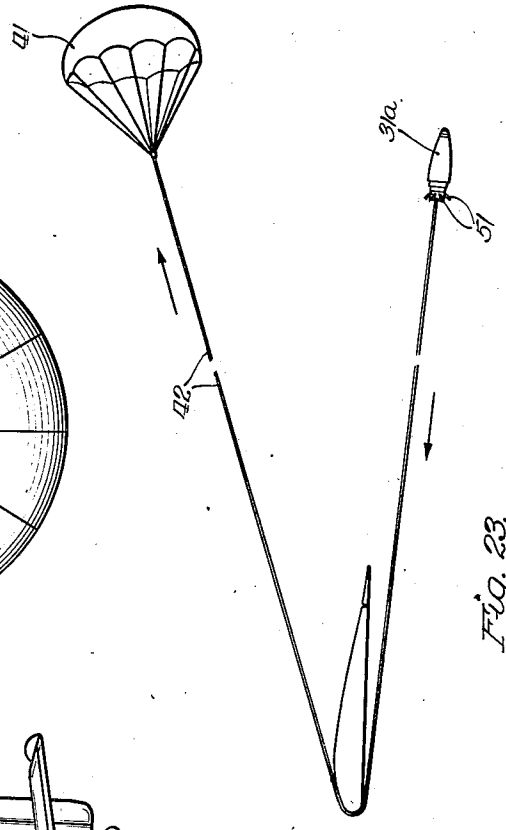
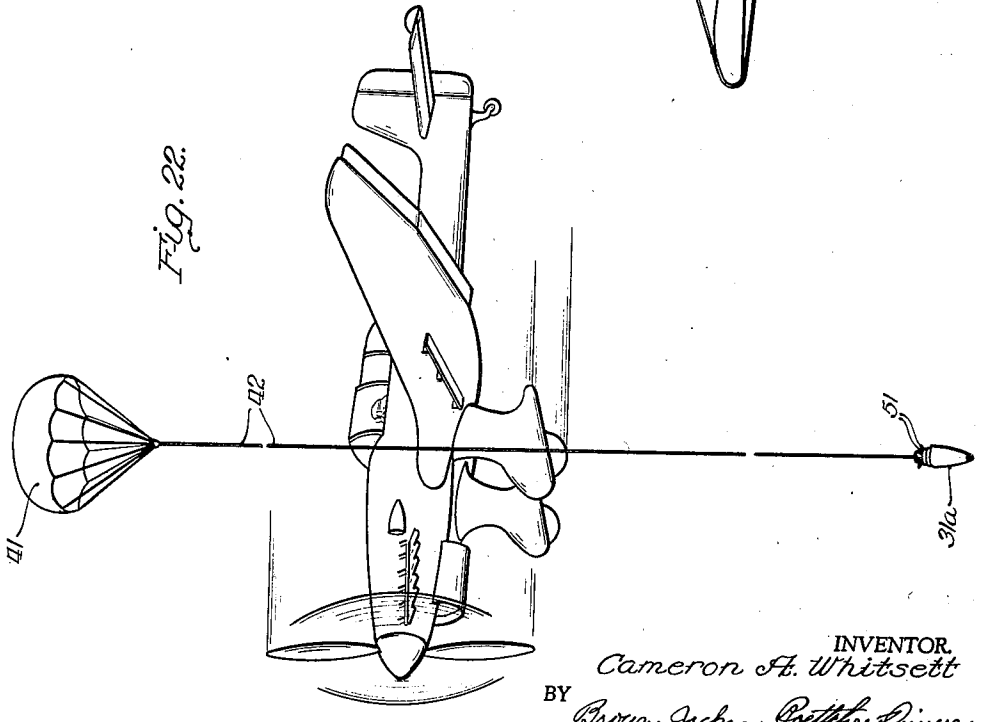


Fig. 23.

Fig. 22.



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ANTIAIRCRAFT SHELL

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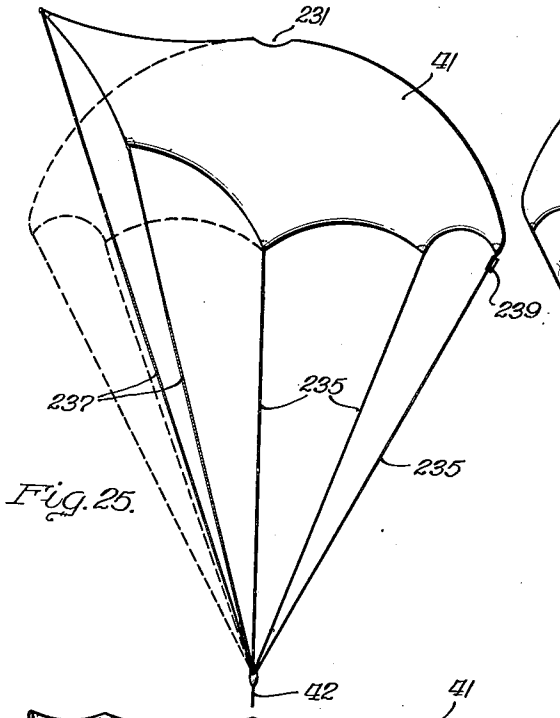


Fig. 25.

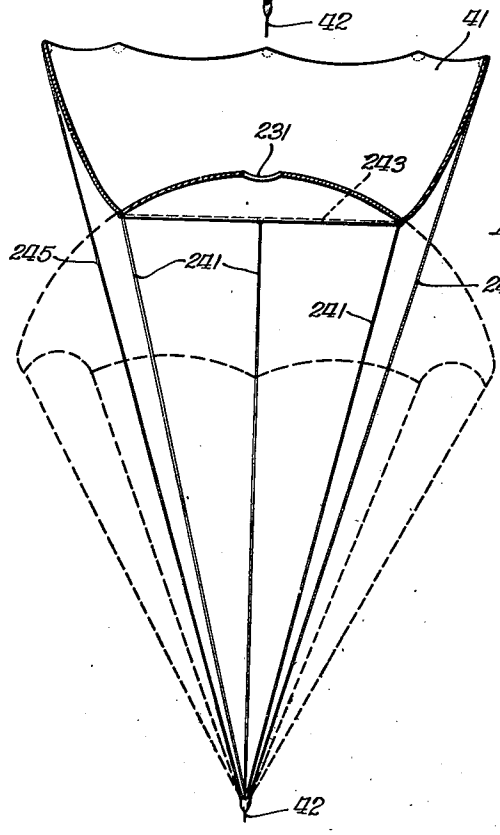


Fig. 26.

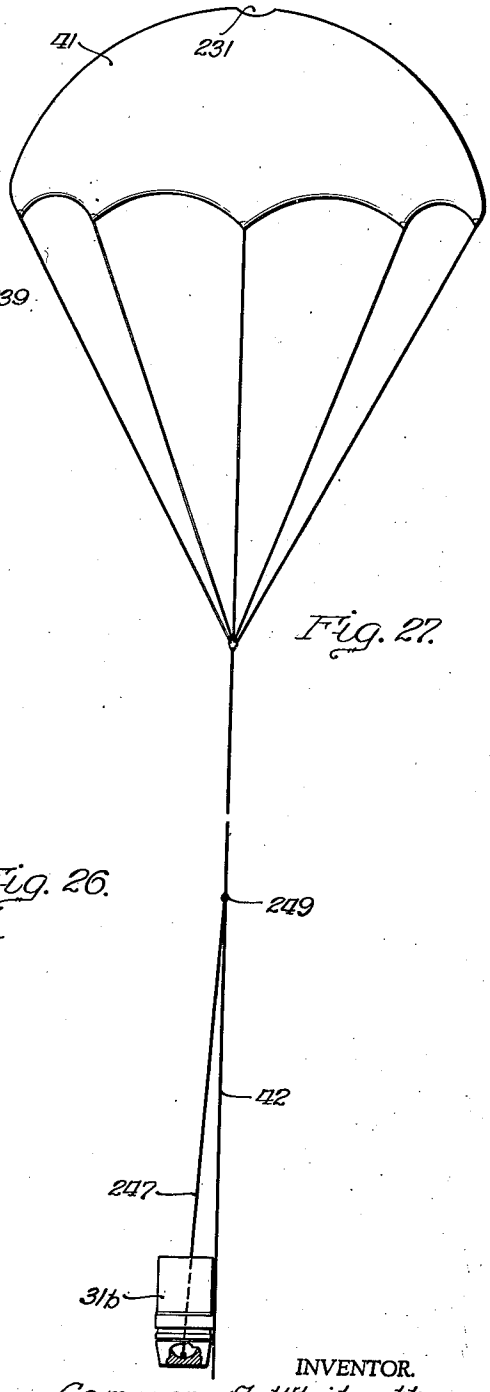


Fig. 27.

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Fig. 29.

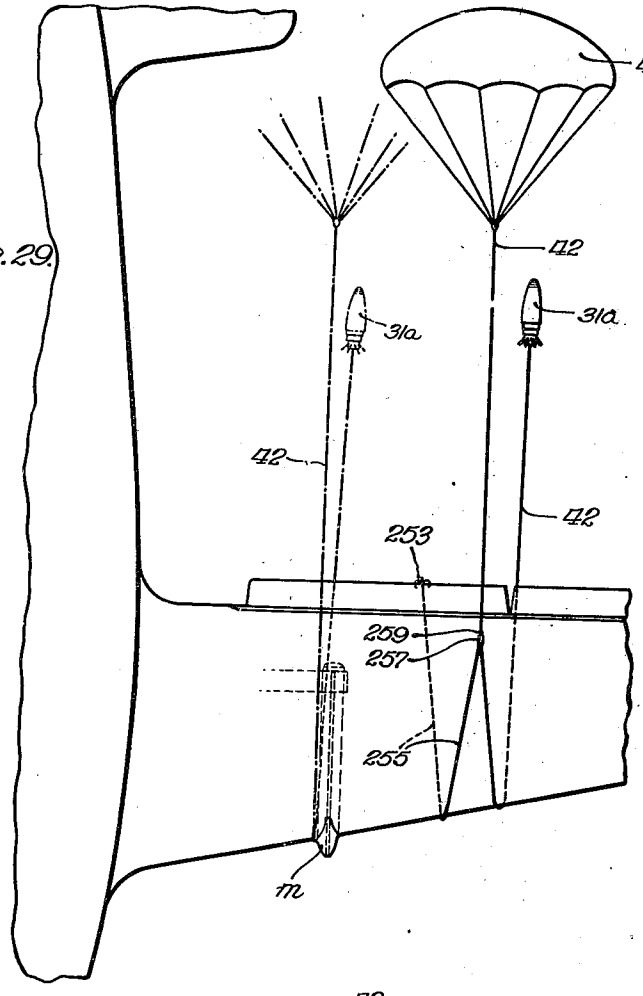


Fig. 28.

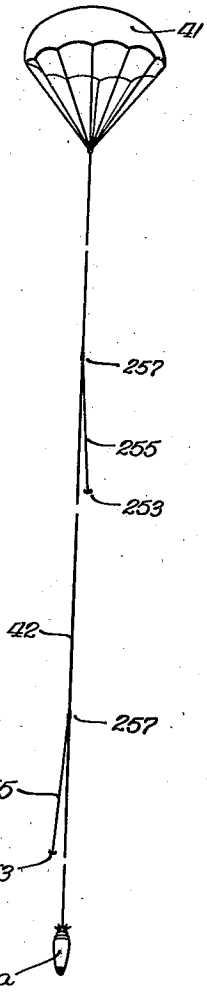
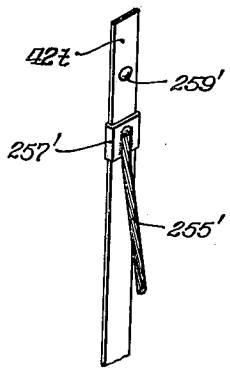


Fig. 31.



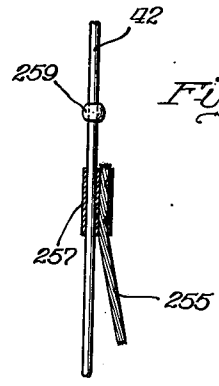


Fig. 30.

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Patented June 25, 1946

2,402,716

UNITED STATES PATENT OFFICE

2,402,716

ANTIAIRCRAFT SHELL

Cameron A. Whitsett, Chicago, Ill.

Application October 18, 1940, Serial No. 361,761

11 Claims. (Cl. 102—56)

1

The present invention relates to improvements in anti-aircraft shells and like devices for combating airplane attacks. In its preferred embodiment, the invention is in the form of a projectile adapted to be fired from antiaircraft guns of the larger calibers, such as three inch, 75 mm., 90 mm., and upward. However, as I shall hereinafter describe, certain features or adaptations of the invention may also be used in projectiles of smaller calibers and in other types of anti-aircraft devices.

The shell as it is fired from the antiaircraft guns comprises a settable time fuse, a charge of black powder or the like which serves to part or open the shell at the altitude predetermined by the time fuse, a parachute which is released from the shell following the opening thereof, and a reel of wire which is also released from the shell and which hangs down from the parachute and suspends an explosive portion of the shell at its lower end. This concept of having an explosive portion of the shell hanging from the lower end of the parachute wire, in the general nature of an aerial bomb or mine, constitutes one of the distinctive features of the invention. The wire in itself can inflict substantial damage against an aircraft running into it at high speeds, but the explosive shell carried by the wire greatly increases the destructive potentialities of the device against aircraft. In the preferred embodiment of the invention, this explosive portion of the shell is adapted to be fired by any direct contact with an aircraft, the charge preferably being a typical high explosive, such as TNT, which produces complete fragmentation of the shell and a high pressure wave. The high explosive charge is fired by a novel trigger mechanism which is tripped by an endwise or sidewise contact with an airplane. The steel wire extending downwardly from the parachute to the explosive shell may be several hundred feet long, and it is the theory of operation of the device that in the event of an airplane flying into the wire, the parachute and wire will coact to guide the explosive shell into direct contact with the airplane. In view of the fact that it is only when the shell is either in direct contact with the ariplane, or is in very close proximity thereto, that detonation occurs, it follows that even a moderately small charge of high explosive in a small caliber shell can effect very destructive damage on practically any size or type of airplane.

The defensive value of my improved parachute shell can be best illustrated in the case of a dive bomber striking the long span of intervening

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wire while in a steep angle bombing dive. Because the angle of such a dive is usually almost as steep as the vertical angle of the suspended wire, there is a relatively small shock of impact placed upon the wire by the wing or fuselage of the airplane striking it, the relatively small horizontal component of the plane's motion pushing the wire ahead of it, and the relatively large vertical component of the plane's motion virtually running down the length of the wire toward the explosive shell, so that the wire guides the shell into direct firing contact with the airplane. Should any whip action occur in the lower portion of the wire as the plane nears the shell, this will only throw the shell more forcibly against the plane.

In the case of a horizontally flying airplane striking the vertical wire, the shock of impact against the wire and the resulting jerk on the parachute and on the explosive shell will be considerably greater than in the case of a diving plane striking the wire. However, my improved construction embodies shock absorbing features which yield under these higher stresses and avoid breakage of the wire or disruption of the parachute. When the leading edge of the airplane wing or fuselage strikes the wire, it jerks the intervening portion of the wire forwardly, with the result that the parachute and shell swing vertically toward each other in rear of the airplane, so that the parachute, the wire, and the shell are dragged forwardly in the form of a V-shaped horizontal loop. After the initial shock of impact has been absorbed, and the parachute and explosive shell have taken on the approximate velocity of the airplane, the parachute will begin to exert a greater drag on its end of the steel wire than the shell does on the other end of the wire, with the result that the parachute will have a relative dragging motion to the rear, thereby drawing the shell forwardly and into firing contact with the plane.

The average bombing plane, pursuit plane, or other combat plane usually has various projections extending forwardly from the leading edge of the wing structure, which projections would serve very effectively to prevent the span of steel wire from slipping laterally off the tip end of the wing. For example, machine guns built into the wing structure usually have their barrels projecting forwardly in such position that they would serve as projections for limiting outward movement of the wire, and the same would also be true of pitot tubes and the like projecting forwardly from the wing structure for con-

nection to flying instruments, etc. Also, in multiple engine planes, the catching of the wire in the span between engine nacelles would insure that the wire could not possibly slip laterally off either wing tip. However, the invention also contemplates as an adjunct for maximum effectiveness against planes having pronounced sweepback of their wing structures, the use of supplementary grappling wires and grappling hooks which are arranged to have a friction slip-fit connection with the main wire. The purpose of such grappling hooks and wires is to establish a hooked engagement against the trailing edge of the wing structure or other adjacent part of the airplane so as to prevent the main span of wire from sliding outwardly along the wing structure toward the tip end of the wing, this being hereinafter described more in detail.

The parachute is made as invisible as possible to enemy aircraft, either by constructing it of a very translucent material, or by coloring it with a very inconspicuous or camouflaging color. The steel wire need only be of very small gauge and is hence invisible only a few feet away, and the explosive shell is relatively small. Consequently, to a plane traveling 200 or 300 miles per hour, the parachute shell would be extremely difficult to see before being actually struck by the plane. The possibility of a plane shooting down these parachute shells with machine gun fire would be extremely remote because of the relatively small size of the parachutes, and the fact that a few bullet holes would not seriously impair them.

Another feature of the invention resides in providing improved safety means in the shell for preventing the detonation thereof when the shell strikes the ground. This safety feature greatly reduces the damage done to dwellings, personnel, etc., by shells which drift to the ground in populated areas. Still further, this safety feature renders a large proportion of the shells which settle to the ground recoverable so that the shell can be recharged and the parachute reclaimed for future use. Hence, the cost of a large scale aerial barrage based on the use of these parachute shells is greatly reduced because of the large proportion of recoveries of unexploded shells.

In a typical use of my improved antiaircraft projectiles, a large barrage of them might be periodically or continuously fired in a predetermined pattern or grouping from the antiaircraft guns so that the individual parachute shells descending therefrom would form in effect an aerial curtain or barrier so positioned as to prevent enemy aircraft from getting within bombing range of a particular ground target. The antiaircraft projectiles can have their fuses timed to open and release the parachutes at any altitude in the trajectory of the projectiles, as for example at altitudes as high as 20,000 to 30,000 feet or more. Owing to the relatively slow rate of descent of the parachutes, it will be evident that the shells which are opened at these high altitudes will require a substantial time to settle down to the ground, ranging anywhere from a quarter of an hour to a half hour or more, depending upon the altitude setting, the size of the parachute, etc. Hence, it will be seen that the defensive value of each shell continues for a substantial period of time throughout the entire range of altitudes at which a bombing attack might be made. Successive salvos of shells may be timed to open at different altitudes for extending or concentrating the vertical barrier formed by the parachute

shells. One of the particular merits of this form of aircraft defense is that it enables the antiaircraft guns to go into immediate action upon any advance warning of an attack, and to establish a defensive barrier of parachute shells a considerable time before the enemy aircraft are even visible. Thus, the defensive value of antiaircraft guns is no longer confined to what may be a very short period of peak fire which is only effective during the time that the enemy aircraft are actually visible; but, to the contrary, by the use of these parachute shells, the guns may be fired continuously at a maximum rate of fire to bring about an "aerial mining" of the sky either in advance of a raid or during a raid. The value of this form of defense is particularly well illustrated in the case of night raids, or raids during cloudy weather, or at extremely high altitudes, when there is very limited visibility for accurately aimed fire of the antiaircraft guns. The latter are usually of the rapid fire type capable of firing 30 or more shells per minute, from which it will be seen that even ten minutes of intensive fire from one of these guns can establish a mined curtain or zone of 300 parachute shells or so. Such aerial mining of the sky over the ground target that is to be protected may be carried on in advance of a forewarned bombing assault until such time as the enemy aircraft have become visible or are within range, whereupon the strategy of fire of some or all of the guns may be changed so as to fire timed high explosive shells in accordance with present day practice.

Other features, advantages, and objects of the invention will appear from the following detailed description of certain preferred embodiments thereof. In the accompanying drawings illustrating such embodiments:

Figure 1 is a longitudinal sectional view through the shell, showing the condition that the shell is in at the time that it is loaded into the antiaircraft gun;

Figure 2 is a fragmentary longitudinal section on a larger scale, showing the front and rear sections of the shell in the act of being parted, preparatory to releasing the wire and the parachute;

Figure 3 is a detail sectional view showing the firing plunger in its forward position in the act of firing the primer, as a result of the front shell section having been brought into firing contact with an airplane;

Figure 4 is a similar view showing the primer shifted down into its safety position, into which it moves when the parachute shell has drifted down and has struck the ground;

Figures 5 and 6 are sectional views taken on the planes of the lines 5—5 and 6—6 of Figure 2;

Figures 7 and 8 are sectional views taken on the planes of the lines 7—7 and 8—8 of Figure 1;

Figures 9 and 10 are fragmentary sectional views taken on the planes of the lines 9—9 and 10—10 of Figure 2;

Figure 11 is a fragmentary sectional view showing the front shell section suspended at the end of the parachute wire, with its trigger mechanism in cocked position ready to be fired by contact with an airplane;

Figure 12 is a detail sectional view of a modified construction corresponding to a section taken on the plane of the line 12—12 of Figure 2;

Figure 13 is a fragmentary sectional view showing a modified operating arrangement between the clutch fingers and the firing plunger;

Figure 14 is a fragmentary side view of the shell with a central portion broken away to illustrate one of the trigger assemblies in its folded position in the shell;

Figure 15 is an end view of the skirt or cage portion of the front piston section, different portions being shown on different section planes;

Figure 16 is a fragmentary detail view of the end ring of the piston assembly;

Figure 17 is a similar view of another portion of the piston assembly;

Figure 18 is a detail sectional view taken on the plane of the line 18—18 of Figure 15;

Figure 19 schematically illustrates a dive bomber striking the intervening wire of the parachute shell;

Figure 20 shows the action of the parachute and wire in drawing the shell into firing engagement with the trailing edge of the airplane wing;

Figure 21 illustrates the shell in the act of striking the underside of the airplane wing, which results in the firing of the shell by lateral contact against the trigger mechanism;

Figures 22 and 23 similarly show the action of the parachute and wire in drawing the shell into firing engagement with the wing or other portion of the aircraft in the case of an airplane flying substantially horizontally;

Figure 24 is a plan view of a modified construction of parachute having elastic upper gussets for yieldingly varying the size of the upper vent opening, so as to minimize shock stress in the parachute;

Figure 25 is a side view of another modified construction of parachute adapted to avoid shock stress by slipping one side of the chute;

Figure 26 is a similar view of still another modified construction of parachute;

Figure 27 is a fragmentary side view of a modified arrangement in which the rear section of the shell remains suspended from the parachute wire after the opening of the shell;

Figure 28 is a fragmentary side view showing another modified arrangement in which grappling hooks and grappling wires are suspended from the parachute wire after the opening of the shell;

Figure 29 is a fragmentary plan view of an air plane wing showing the action of said grappling hooks in preventing the parachute wire slipping off the end of the wing;

Figure 30 is a detail view on a magnified scale showing the mounting and arrangement of such grappling wires on the parachute wire;

Figure 31 is a fragmentary perspective view showing a form of metallic tape which may be used as the suspension member instead of wire; and

Figures 32 and 33 show a modified construction in which the shell is convertible into a timed high explosive type, these views corresponding to a section taken on the plane of the line 32—32 of Figure 1.

Referring to Figure 1, the shell is designated 31 in its entirety, this figure illustrating the shell in the form in which it is fired from the anti-aircraft gun as a projectile. In typical anti-aircraft ordnance, such a shell is the projectile of fixed-load ammunition, although it will be understood that the invention can also be embodied in the projectiles of loose loading ammunition. The main case of the shell comprises a front section 31*a* and a rear section 31*b*, these two sections being joined together at a separable joint 32. Said joint comprises an inner annular

flange 33 carried by the front section, and an outer annular flange 34 carried by the rear section, these two flanges having a relatively tight push fit. Any suitable type of shear fastening may be employed to secure the two sections together, such as shear pins, a shear thread, or a shear wire, etc. In the exemplary construction illustrated, a shear wire 35 composed of brass, aluminum, or other readily shearable metal, occupies the ring-like channel which is defined by the matching grooves 36 of semi-circular cross-section formed in the flanges 33 and 34. The wire may be inserted into said matching grooves, after the shell sections have been assembled, by introducing the wire through a tangential opening leading to said grooves. The rear section 31*b* carries the rotating band 38, and the front section 31*a* is shown as being formed with the bourrelet 39, although the bourrelet might be formed on the rear section if the latter were of considerable length.

Packed within the rear end of the rear section 31*b* is the parachute 41, and disposed forwardly of the parachute is the reel or coil of steel wire 42. Confined within the forward section 31*a* is the charge of high explosive 43, this forward portion of the shell being the explosive portion which is suspended at the lower end of the steel wire 42, as clearly illustrated in Figures 19 to 30 inclusive. Mounted at the forward end of the front section 31*a* is the fuse 44 that gives the variable time delay that enables the shell to be opened at any desired altitude within the range of its trajectory. The fuse shown is a compound or combination fuse structure performing a plurality of fuse functions. For example, there is the time function of determining the time (or altitude) at which the shell is to be opened; and there is also the detonating function of firing the charge of high explosive 43 when the trigger mechanism of the cocked shell has struck against an airplane. I have also shown the fuse structure as performing the third function of a percussion fuse which serves to fire the charge of high explosive 43 in the event of percussion contact of the shell against any part of an airplane structure while the shell is travelling through the upward part of its trajectory, before opening.

The opening of the shell is performed by the firing of an opening or parting charge of black powder or the like 47 which is confined within a chamber 48 formed in the rear end of the front shell section 31*a*. The firing of this opening charge acts against a piston 49 which defines the rear wall of the chamber 48, whereby said piston is forced rearwardly for parting the rear section of the shell from the front section. Such rearward motion of the piston 49 also cocks the trigger mechanisms 51, and places the detonating apparatus in condition to be fired by the trigger mechanisms 51. The foregoing description will afford a general understanding of the main elements of the shell, and I shall now described these different elements in greater detail.

The chamber 53 which contains the high explosive charge 43 is closed at its rear end by the transverse wall or diaphragm 54. As shown in Figure 5, a plurality of filling apertures 55 are provided in this end wall, through which the high explosive is poured in the molten state in the filling operation, these apertures being thereafter closed by the threaded plugs 56. The other end of the high explosive chamber 53 is closed by the fuse plug or fuse head 58, the shank of which screws into a long internal thread 59 formed in

the outer end of the front shell section 31*a*. Extending rearwardly from this fuse plug 58 is an integral tubular stem 61 carrying a threaded closure portion 62 at its rear end, which closure portion screws into a rear internal thread 63 formed in the end wall 54. The front internal thread 59 and the rear internal thread 63 are of the same pitch and are preferably cut at the same time by different size threading hobs on the same cutting tool, so as to receive without binding the two threads on said fuse plug and on said closure portion. An optional method of introducing the high explosive charge 43 into the chamber 53 is to first pour and solidify a filling of the explosive within the chamber through the threaded front end 59, then to drill out a central opening through the exposive or to mold a central opening therein during the pouring and solidifying thereof, thereafter to pass the stem 61 and threaded closure portion 62 through this opening and into assembled engagement within the front and rear threads, and finally to fill all remaining voids in the chamber 53 by supplementary pouring operations through the filling apertures 55.

Extending longitudinally along the length of the tubular stem 61 is a raised rib 65 in which is cored a flashback passage 66 through which the flash of a detonator 67, disposed in the fuse plug 58, is conveyed back to the opening charge of black powder 47 disposed in rear of the partition wall 54. The flash-back passage 66 is clearly shown in Figure 4, and, as shown in Figure 7, the detonator, primer, or like firing charge 67, which may be composed of fulminate of mercury or other suitable type of detonating explosive, is preferably a pellet of arcuate form, packed into an arcuate cavity 68 cored out in the fuse plug 58. Said cavity is open only at its front end, through which the detonating pellet is inserted, and said open end may be closed by any suitable gasket of paper or other ignitable material. This detonator 67 is adapted to be fired by the adjustable time fuse contained within the fuse structure 44, which time fuse has previously been set to open the shell at a predetermined altitude, as will be later described. Preferably, the passage 66 is left open so as to conduct the flash of the detonator 67 as an instantaneous flame discharge back to the charge of black powder 47, but, if desired, a powder train or other fuse medium may be extended through said passage for securing additional time delay, or for any other purpose. The charge 47 for opening or parting the shell is preferably black powder, but might be any other suitable explosive of a relatively slow burning characteristic. This opening charge 47 is preferably enclosed within a thin ignitable container 69 composed of paper, cardboard, fabric, etc., which prevents any frictional contact of the charge with surrounding metal parts under the set-back force which occurs in the firing of the projectile from the gun.

Referring again to the transverse sectional view through the fuse plug 58, Figure 7, the remaining portion of the plug not occupied by the detonator cavity 68 is formed with a second relatively long arcuate cavity 71 in which is enclosed a booster charge 72, also preferably in the form of an arcuate pellet, composed of tetryl or other suitable booster explosive. This booster pellet is packed into the open rear end of the latter cavity 71, and is retained therein by a thin sheet metal gasket or cover 73 pressed into the cavity. This booster charge is provided for the purpose of igniting the high explosive charge 43, the booster charge blowing the cap 73 rearwardly from the open rear end of the cavity 71. Said booster charge is fired through a passageway 74 by a primer 75 which is disposed substantially centrally within the fuse structure 44, this primer being fired as the first step in the bursting charge train, through the impingement action of a Semple centrifugal plunger 76 or other suitable firing mechanism, as I shall presently describe.

Formed as an integral extension of the fuse plug 58 is a forwardly projecting central sleeve 81 which has an internal thread 82 at its front end. Screwing into said thread is a companion thread formed on an inner sleeve 84 which projects forwardly from the outer sleeve. Said inner sleeve has its outer end formed with a spider structure or apertured head portion terminating in a forwardly extending central boss 86. A semispherical end cap 88 screws over a thread on this boss 86. A plurality of venting passages 89 are cored out in the end cap 88, these venting passages communicating with other venting passages 91 extending through the aforementioned spider structure and opening into the chambered interior of the inner sleeve 84. These venting passages may be utilized for interior venting of the time-train rings 92 and 93, and may also be utilized for venting the primer 75 if the latter should become accidentally fired upon striking the ground after the primer has been moved forwardly to its safety or non-firing position.

Slidably mounted in a cylindrical bore 95 formed coextensively in the thread boss 86 and end cap 88 is a conventional concussion plunger 96 which is normally held in the forward position shown in Figure 1 by the friction ring 97 engaging in the grooved exterior of the plunger, this being a well kown construction in powder-train time fuses. The set-back force which occurs when the shell is fired from the gun frees the plunger from the friction ring, and the resultant inertia effect carries the plunger against the concussion firing pin 98, as shown in Figure 2, so that the concussion primer in the plunger is fired. The flash from this primer is conducted laterally through a passage 99 which extends through one arm of the spider structure and opens into the annular powder channel of the outer time-train ring 92. The powder in this channel burns around to a point where it meets a port which is formed in the front surface of the next time-train ring 93, which port conducts the delayed combustion into the annular powder channel of this next time-train ring 93. The latter ring is rotatable to different angular positions relatively to the front ring 92, thereby increasing or decreasing the total length of the powder train in the two rings and hence varying the altitude adjustment at which the shell is set to be opened for parachute descent. The structure and operation of such powder-train time fuses are old and well known and need not be described in any greater detail, reference being had to pages 589–592 of "Elements of Ordnance," by Hayes, for complete disclosure of one typical construction which may be employed. This construction may be such that the combustion in the second time-train ring 93 will be conducted from one angular point in its powder channel directly to the detonator 67 which fires the opening charge of black powder 47, as previously described. As illustrative of an alternative construction, I also propose adding a stationary spacer ring 102 and a third rotatable ring 103. The spacer ring 102 is held against rotation by a kerf or key 104 (Fig-

ure 10) projecting inwardly therefrom and seating in a keyway 105 formed longitudinally in the outer end of the sleeve 81. A single port 106 in this stationary ring establishes communication between the second and third powder train rings 93 and 103. The powder channel in said third ring transmits the firing propagation into the detonator 67. This occurs through a rearwardly facing port 108 in said third ring which can be turned into and out of registration with the detonator by rotating said third ring. As shown at the lower side of Figure 2, said third ring also carries a right angle port 109 which is adapted to establish right angle communication between the primer 75 and the passageway 74 leading to the booster charge 72. It will be seen from the foregoing that this third ring 103 can be utilized as a safety ring, since by rotating this ring to a safety position the port 108 can be turned out of registry with the detonator 67, and the right angle port 109 can be turned out of registry with the booster charge 72, thereby increasing the safety factor of the shell during storage and handling. This third ring 103 would be rotated back to its firing position at the same time that the second ring 93 is rotated to the set position which predetermines the altitude at which the shell is to open. Said third ring is also adaptable to other utilities, such as for increasing the total length of powder train in order to give a greater time delay for higher altitudes, and as a still further utility to enable the shell to be converted into a timed high explosive shell in which the high explosive charge 43 can be exploded at different adjusted altitudes by direct detonation from the powder ring time train through the booster charge 72, without releasing the parachute 41. This will be described later. The three powder train rings 92, 93 and 103 can all be vented exteriorly, or can all be vented interiorly through passages 89 and 91, or two rings can be vented one way and the other ring the other way.

The primer 75 which fires the booster 72 and high explosive 43 is contained within a slidable metallic thimble 115 which is provided with a radial stop flange 116 at its front end and a radial stop flange 117 at its rear end. The cylindrical body of the thimble has a snug sliding fit within a ring 118 which is pinned or otherwise secured within the end of the sleeve 84. The abutment of the front radial flange 116 against the front end of the ring 118 defines the limit of rearward movement of the thimble (Figures 1 and 2), and the abutment of the rear radial flange 117 against the rear ends of the ring 118 and sleeve 84 defines the limit of forward movement of the thimble (Figure 4). The thimble is prevented from rotating in said ring by the provision of a spline 119 in the ring engaging in a groove in the thimble (Figure 10), or by any other suitable keying arrangement. The purpose of having the primer thimble shiftable between rear and front positions has to do with rendering the parachute shell non-explosive when the shell has drifted down to the ground and the nose of the shell has struck the ground. This takes the weight of the shell off the length of steel wire and permits the primer thimble 75 to jump forwardly or downwardly to its safety position (Figure 4), as I shall presently describe. When the primer thimble is in its rearward or upward firing position (Figures 1 and 2), the thimble chamber is in position to fire laterally through a plurality of radially extending ports 121 (Figure 3) which register with stationary ports 122. These stationary ports 122 in the ring 118 and sleeve 84 open into the right angle port or ports 109 formed in the third powder ring 103, leading to the booster charge 72. When the thimble is shifted forwardly to its safety position (Figure 4), the thimble ports are carried out of registry with said stationary ports and into registry with the chambered interior of the sleeve 84, forwardly of the ring 118. It will be noted from Figure 10 that the front stop flange 116 has scallops or apertures 124 therein which establish venting communication forwardly to the venting passages 89, 91. Hence, if the percussion plunger 76 should fire the primer 75 after the primer thimble has shifted forwardly or downwardly to the safety position it assumes as soon as the nose of the shell touches the ground, such firing of the primer will be vented out through the front vents 89 and 91, with very little likelihood of the booster charge 72 being fired. This means that a large percentage of the parachute shells drifting to the ground will be prevented from exploding upon contact with the ground or buildings, etc., and these shells can be recovered and recharged for future use.

A shifter spring 126 is confined under compression within a cylindrical bore 127 in the fuse plug and bears against the rear radial flange 117 of the primer thimble, tending constantly to shift the primer thimble to its forward safety position. Acting in opposition to said shifter spring are a plurality of angularly spaced rods 128, preferably four in number (Figures 7 and 8), which have their front ends anchored in the primer thimble so that they can hold the thimble drawn back in its firing position. These rods pass freely through guide openings 129 extending entirely through the percussion plunger 76, said rods having their rear ends secured to a disc or head 131 which is fastened to the front end of a long spring suspension sleeve 132. Confined within said sleeve is a very long cushioning spring 133, which affords a spring cushioned suspension of the explosive portion of the shell at the lower end of the steel wire 42 during the parachute descent. Said spring surrounds a plunger rod 134 which carries a piston head 135 at its forward end against which the cushioning spring bears. The other end of said spring bears against a guide bushing 136 which is secured in the rear end of the spring suspension sleeve 132, and through which bushing the spring rod 134 is guided. The outer end of said rod is provided with a head 137 to which the lower end of the steel suspension wire 42 is anchored. The aforementioned shifter spring 126 has a compression pressure which is less than the weight of the explosive portion 31a of the shell, and hence when this portion of the shell is hanging suspended from the parachute the weight of the shell is transmitted through the cushioning spring 133, sleeve 132 and rods 128 to the primer thimble 115, for holding the thimble in its retracted firing position against the pressure of said shifter spring 126. However, when the nose of the shell strikes the ground or other supporting surface in the parachute descent of the shell, the weight of the shell is taken off the spring suspension sleeve 132 so that the shifter spring 126 can shift the sleeve 132, rods 128 and primer thimble 115 forwardly for placing the primer thimble in its safety position (Figure 4). The long cushioning spring 133 is preferably relatively stiff so that the weight of the explosive portion of the shell only compresses said spring a relatively small amount during parachute descent. One of the primary objects of said cush-

ioning spring is to cushion the shock load placed upon the wire when a horizontally flying airplane strikes the wire, and to this end the cushioning spring has a very long range of relatively high deflection pressure for absorbing impact shock. In the condition in which the shell leaves the muzzle of the antiaircraft gun, the primer thimble 115 is held back in the firing position shown in Figure 1 by a releasable split wire ring 138 which engages in an annular groove 139 formed in the forward portion of the spring suspension sleeve 132. This locking ring locks said sleeve and primer thimble in the forward positions shown until the shell is opened for parachute descent, as I shall later describe.

Referring now to the percussion plunger 76, this device is slidable along the rods 128 and is provided with an outwardly extending flange 142 having guided movement within the relatively large cylindrical bore 127. The shifter spring 126 has its rear end bearing against said flange, and thereby tends to hold the plunger in its rearward position, with the flange 142 abutting against the rear end of the large bore 127. Extending rearwardly through the stem 61 from said large bore is a smaller bore 144 which continues throughout the length of the stem. A sleeve extension 145 is formed integral with or is secured to the plunger 76 and extends rearwardly a short distance within the bore 144. When any of the trigger mechanisms 51 strikes an airplane and is tripped, a forward firing impetus is imparted to said sleeve extension for carrying the plunger 76 forwardly into firing engagement with the primer 75, as I shall hereinafter described.

The percussion plunger 76 preferably contains a safety type of firing pin mechanism which will make the projectile "bore-safe," i. e., prevent the firing pin moving into effective position until after the projectile has left the bore of the gun. The Semple type of firing pin responsive both to centrifugal force and inertia is representative of one form of bore-safe firing pin which may be employed, although other constructions may be used instead. The details of this Semple construction are known in the field of ordnance (see pages 579, 580, 581, and 590 of "Elements of Ordnance," supra), and accordingly it is not necessary to describe it in all detail here. Briefly, the firing pin 76' projects from a weighted segment 147 which is arranged to swing in a longitudinal slot 148 in the plunger around a transverse pivot pin 149 (see Figures 7 and 8). Normally, the segment is positively locked in the position shown in Figure 1, with the firing pin inclined at a non-effective angle, through the locking function of centrifugally responsive plungers 151 which are slidably mounted in aligned transverse bores intersecting the longitudinal slot 148. Compression springs 153 thrust inwardly against said locking plungers, these springs preferably extending into hollow interiors of said plungers. The plungers normally extend into a locking opening 155 formed in the segment 147, both plungers abutting against each other midway of the depth of said locking opening. In such position of the plungers, the segment 147 is positively locked against swinging movement around pivot pin 149. In the firing of the projectile from the anti-aircraft gun, the high rotative speed imparted by the rifling sets up a substantial centrifugal force in the shell, which impels the locking plunger 151 outwardly so that the segment 147 is free to pivot forwardly around the pin 149. The weight of the segment is so disposed with reference to the fulcrum pin 149 that centrifugal force will tend to turn it about said pin and arm the device by placing the firing pin 76' in a forwardly extending position. However, if there is considerable longitudinal acceleration of the projectile, which is the condition until it leaves the muzzle of the gun, the disposition of weight of the segment and firing pin with respect to the pivot pin 149 are such as to cause a turning effect opposite to and greater than that caused by centrifugal force. This feature prevents the firing pin from arming until after the projectile has left the gun, such armed position being illustrated in Figure 2. The firing pin now being armed, the shifter spring 126 prevents the firing plunger moving forwardly by creep force while the projectile is in flight.

By virtue of the above arrangement of primer thimble and percussion plunger, the shell is armed for direct percussion or graze fire practically as soon as the shell has left the muzzle of the gun. That is to say, if any of the shells being fired upwardly in barrage fire or otherwise should strike an airplane, the sudden deceleration or inertia shock on the shell will cary the firing plunger 76 forwardly into firing engagement against the primer 75, thereby igniting the booster charge 72 and exploding the high explosive charge 43. This percussion detonation will occur even if the shell should strike only a relatively frail part of the aircraft, since the plunger 76 is relatively sensitive to percussion inertia. In such percussion shock, the primer thimble 115 cannot move forwardly out of its firing position because of the locking retention exerted by the locking ring 138 engaging in the groove 139 in the rearward portion of the sleeve 132. This locking ring is not forced out of said groove until the shell is opened for parachute descent.

Referring now to the arrangement whereby the tripping of the trigger mechanisms 45 imparts firing impetus to the firing plunger 76, it will be noted that the shell-opening piston 49 has a threaded mounting 158 on a long guide sleeve 159 which has a free sliding fit over the spring suspension sleeve 132. Surrounding said guide sleeve, within the rear half of the cylindrical bore 144, is a heavy compression spring 161 which is shown as being coiled of circular wire stock but which might be coiled of flat bar or ribbon stock for greater stiffness, if desired. The rear end of said spring abuts against a threaded bushing 162 which screws into the rear end of the bore 144, the sleeve 159 being guided in said bushing. The front end of said spring bears against a shiftable ring 163 which is free to run back and forth in the bore 144. The spring 161 is preloaded with a substantial pressure, and this is borne at the front end by the slidable ring 163 bearing against a stationary stop ring 165 which is rigidly anchored within the bore 144, as by the radial pins 166 or in any other suitable manner. It will be observed that this stop ring is of small radial thickness, so as to leave substantial clearance between the inner periphery of the stop ring and the outer periphery of the sleeve 159. A shouldered end head 167 secured fast to the end of the sleeve 159 is sufficiently thin so as to be capable of moving rearwardly through said clearance space and picking up the shiftable ring 163. Hence, in the operation of parting or opening the shell by the firing of the parting charge of black powder 47, the rearward movement of the piston 49 and sleeve 159 will pick up the preloaded compression spring 161 and compress this spring to a substantially greater pressure, as

shown in Figure 2. Said spring may be so proportioned that the condition of the spring becoming solid constitutes the end stop which determines the rearward limit of movement of the piston 49 and sleeve 159, or the engagement of the spring fingers 171 against the rear ends 172b of the slots 172 may function as such, as described below. As the piston and sleeve approach the limit of this rearward movement, a plurality of spring fingers 171 moving therewith snap outwardly into openings 172 which are formed in the rear portion of the sleeve extension 145 projecting rearwardly from the firing plunger 76. These spring fingers function to establish a clutched engagement between the sleeve 159 and the sleeve extension 145, said clutched engagement preferably permitting a limited amount of endwise lost motion between the two. The fingers are preferably formed integral with or are secured to the shouldered end head 167 which is secured fast to the sleeve 159, being of resilient construction and so biased that they tend constantly to spring outwardly. Said spring fingers have shouldered ends 171' which are capable of effecting a positive engagement against the right angle shoulders 172a and 172b at the front and rear ends of the slots 172. To insure that at least one or more fingers will engage in one or more slots, there may be an even number of one and an odd number of the other, or, as shown in Figure 12, the clutch fingers may be guided endwise between pairs of longitudinal guide ribs 173 projecting outwardly from the sleeve 132. Normally, the shouldered ends of the fingers ride on the solid forward portion of the sleeve extension 145. As the shell opens for the ejection of the parachute, the shouldered ends of the fingers travel rearwardly and outwardly into the slots 172 and continue back to a position where they abut the rear ends 172b of said slots, or are in close proximity to these rear ends. This establishes a clutched relation between the sleeves 159 and 145 during the parachute descent of the shell, whereby the inertia shock set up in the shell by a high speed airplane striking the suspension wire 42 along a substantially horizontal flight path will not jar the sleeve 145 and percussion plunger forwardly into firing engagement with the primer 75. However, when the suspension wire 42 guides the explosive portion of the shell into contact with the airplane, and the trigger mechanism 51 is tripped by such contact, the quick forward motion of the sleeve 159 brings the clutch fingers up against the right angle front ends 172a of the slots, thereby picking up the sleeve 145 to travel therewith and driving the percussion plunger 76 home into firing engagement against the primer 75.

Referring now to the shell opening piston 49 and the trigger mechanism 51, the piston assembly is of two-part or divided construction, comprising the front section 49a and the rear section 49b. When the opening charge of black powder 47 is fired, the two sections of the piston start back together and continue their travel together until the rear section 31b of the shell has been separated from the front section 31a and until the triggers 51 are free to fly outwardly to their cocked positions, whereupon the rear section 49b of the piston separates from the front section 49a and continues its rearward motion after the front section stops, such relative separation between the piston sections enabling the trigger linkages 51 to swing outwardly to their cocked positions (Figure 2).

The front piston section 49a comprises a relatively long cylindrical skirt portion 174 which serves the dual purpose of a pusher element for separating the shell sections and also of a confining cage in which are mounted the trigger linkages. This cylindrical member might be made integral with the front piston section 49a, although for facility of manufacture and assembly I preferably make it as a separate piece and form an internal ring portion 175 at its forward end, which ring portion is internally threaded to screw over the external thread 176 on the periphery of the front piston section, as best shown in Figures 15 and 18. An end ring 178 is secured against the front end of the cylindrical skirt member 174 by screws 179 (Figure 18) which pass through openings in the ring and thread into tapped openings in the cylindrical member, this ring completing the outer peripheral portion of the front piston section 49a and having a moderately close sliding fit within the chamber 48. If desired, the inner periphery of this ring may be threaded for screwing over the external thread 176, or over a continuation of such thread, before being anchored by the screws 179. In the parting of the shell, the separating force exerted by the piston is transmitted rearwardly through the cylindrical cage or skirt portion 174 against an abutment ring 181 which has threaded anchorage at 182 within the rear section 31b of the shell. This separating force shears the relatively soft shear ring 35, as shown in Figure 2, and then completely separates the two sections at the joint 32, following which the rear section of the shell drops back quite rapidly because of its increased air resistance. Final venting of the remaining force of the black powder preferably occurs through a series of vent holes 184 which are formed in the inner flange 33, these being uncovered by the outer flange 34 and by the piston 49 in the rearward movement of said latter members. If desired, the stroke of the piston may be increased, or the parts othrewise proportioned, so that venting will occur past the end ring 178 and outer edge of the flange 33.

Referring now to the trigger devices 51, these swing outwardly from the skirt portion of the piston as soon as the rear shell section 31b has cleared the end of said skirt portion (Figure 2). As best shown in Figures 14–18, there is a series of these trigger devices grouped in angularly spaced relation around the piston and said cage portion, eight of such trigger assemblies being shown although the series may consist of only six or any other number. Each trigger assembly comprises a central T-shaped link 187 and two side links 188 pivoted together at 189 for outward and inward folding motion. Each of these link assemblies folds inwardly into an individual rectangular recess 191 formed in the piston skirt 174 (Figure 15), so as to be received completely within said skirt portion. These recesses extend entirely through the thickness of the skirt portion from end to end thereof; except that near the front end the under sides of the longitudinal bar portions 193 are formed integral with the threaded ring portion 175 (Figure 14).

The forward end of each T-shaped link 187 is formed with a pivot boss 195 which fits between two pivot lugs 196 projecting rearwardly from the end ring 178, a pivot pin 197 passing through said lugs and boss. By reason of the fact that the end ring and lugs constitute a separable unit, the T-shaped triggers 187 can all be pivoted thereto before assembly in the skirt portion. The

rear extremity of each T-shaped link is formed with laterally extending side bar portions so as to increase the area or span of the outer end of each link effective for contact against an airplane.

Coil springs 199 are arranged to act between each T-shaped link and its two side links 188, these springs being preferably coiled around the axes of the pivots 189 which join said links. The ends of said wire springs are hooked into notches or apertures in said links, and the bias of said springs tends constantly to swing the links outwardly, with each T-shaped link and its associated side links tending to open up or separate from each other around the axis of the knuckle pivot 189. Small pivot bosses 201 may project laterally from the sides of the T-shaped lever 187 to space the side links 188 therefrom for accommodating said coil springs, or the pivot pins 189 themselves may provide lateral shoulders for spacing the side links.

The forward ends of said side links 188 have pivotal connection with the rear piston section 49b at the shiftable pivots 202. Said rear piston section is capable of sliding movement toward and away from the front piston section 49a, being provided with a central guide boss or hub 203 which has a free sliding fit on the spring suspension sleeve 132 (Figure 2). Projecting outwardly and rearwardly from this piston section at spaced points around its periphery are pairs of parallel bars 204. These bars first extend outwardly a short distance and then extend rearwardly within the rectangular openings 191 in the cage portion 174. As best shown in Figure 14, each pair of parallel bars has close sliding fit along the parallel side walls of its associated rectangular opening. The pivot pins 202 pass through said parallel bars adjacent to the rear piston section 31b, and then pass through the forward ends of said side links 188. These side links are adapted to fold down into the spaces which are defined between the parallel side bars and the central T-shaped link 187 (Figure 14). The rear ends of said pairs of parallel bars are secured to or formed integral with a continuous abutment ring 205 disposed immediately beyond the rear end of the cage or skirt portion 174. It will be seen from the foregoing that the rear piston section 49b, its central hub 203, pairs of parallel bars 204 and rear abutment ring 205 constitute a movable cage structure which is shiftable as a unit relatively to the front piston section 49a and its cage or skirt portion 174. The aggregate pressure of the multiplicity of coil springs 199 mounted on the several trigger assemblies 51 tends constantly to shift the rear piston section and its cage structure rearwardly by the action of urging the trigger assemblies outwardly to their cocked positions. The rearward limit of this relative shifting motion may be defined by stop links or like devices effective between the front and rear piston sections for limiting their relative separating movement. However, in the preferred construction illustrated in Figures 14, 15, and 18, the stop means is effective between the cage structures of the pistons, such comprising stop shoulders 207 carried by the front skirt or cage portion 174 engaging in longitudinal slots 208 formed in the pairs of parallel bars 204 of the rear cage portion. The stops 207 are in the form of studs projecting outwardly from radial side edges of small attachment plates or clips 209 which are secured to the rear extremities of the longitudinal bar portions 193 by screws 211 threading into tapped holes in said bar portions. These stop plates 209 need only be mounted on a few of the longitudinal bar portions 193, the screws 211 being inserted when the rear cage structure is shifted to its backward position as shown in dotted lines in Figure 14. The slots 208 in the parallel bars 204 may be of any desired length for stopping the rearward movement of the shiftable pivots 202 at any desired point. This point determines the angular position which the side links 188 will assume relatively to the central levers 187 when the trigger assemblies are cocked. In this cocked position, the outer edges of the central levers have trigger contacts at the points 213 against the inner edge of the flange 33. Said levers and links in this cocked position define triangular struts which must be collapsed in the tripping of the triggers. The angle of inclination of the side links 188 is such that these triangular struts have just sufficient strength to resist the forward pull of the relatively heavy compression spring 161 acting through the sleeve 159. That is to say, a relatively small tripping force is adequate to collapse the triangular strut relation of the links and permit the links and piston to jump forwardly or downwardly under the impetus of the spring 161, such motion carrying the clutch fingers 171 against the forward ends of the slots 172 and driving the firing plunger 76 into the primer 75 with resulting detonation of the high explosive 43. Referring to Figure 11, it will be clear that a relatively slight tripping force striking longitudinally against any point of the end ring 205 of shiftable rear cage 204, in the direction of the arrows X, will immediately collapse the strut relation of all of the links by carrying the shiftable pivots 202 downwardly, thereby permitting an instantaneous inward folding of all of the links. It will be noted that such direction of tripping blow is most likely to occur whenever the explosive portion 31a of the shell is being dragged into firing contact with the airplane through the pull of the wire 42. Such direction of tripping blow is still effective even if it should miss the ring 205 but strike any one of the side links 188. The tripping of the trigger links will also result from the striking of a blow inwardly against the outer ends of any of the T-shaped links, as indicated by the arrow *y* in Figure 11. This will exert a collapsing force tending to drive the rear piston section toward the front piston section, so that all of the trigger assemblies will collapse or fold inwardly simultaneously, with consequent forward motion of the firing plunger and detonation of the shell. Such direction of tripping blow is most likely to occur in any whipping or sidewise swinging of the shell against a surface of the airplane.

In Figure 11, I have illustrated a modified construction in which trigger notches 213' of approximately right angle form are cut in the outer edges of the T-shaped levers 187 for engaging against the right angle inner edge of the flange 33. These trigger notches may be desirable for greater certainty of latching engagement against said flange, such as to reduce the likelihood of accidental firing in the case of descending parachute shells being blown sidewise against buildings or other vertical surfaces by relatively strong winds.

In this Figure 11, I have also illustrated a supplementary or alternative feature in the provision of a moderately heavy compression spring 215 which has its ends confined in cylindrical pockets 216 and 217 formed in the front and

rear piston sections. This spring tends to maintain the trigger links in their strut relation, and the pressure of said spring must be overcome in the tripping of said links for detonating the shell. Said compression spring may supplement the coil springs 199 mounted on the trigger links, or it may be employed in lieu of said coil springs, in which latter case the centirfugal force of the rotating shell may be relied upon to project the trigger links outwardly in the opening of the shell, or the shiftable pivots 202 may be located inwardly of a dead center line between the pivots 189 and 197 so as to exert an outward force on the links in the opening of the shell.

It is opportune to remark at this point that in the preferred construction, the combined thickness of the two flanges 33 and 34 is depended upon to give the required strength at the separable joint 32 to withstand the set-back force which arises in the firing of the shell from the anti-aircraft gun, without regard to the relatively movable piston sections and their cage portions; but that, if desired, these piston sections and their cage portions might be arranged to sustain a substantial part of the set-back force if it is desired to reduce the thickness of the flanges 33 and 34, for space considerations or otherwise. It will be understood that in the opening of the shell, the explosive force of the charge of black powder is transmitted through the solid portions 193 of the front cage and through the ring 205 of the rear cage into engagement against the abutment ring 181 which is screwed into the rear section of the shell.

Referring to the wire 42, this is preferably a drawn steel wire of extremely high tensile strength comparable to so-called piano wire, having a tensile strength of upwards of 300,000 pounds per square inch. Assuming the explosive portion 31a of the shell to weigh in the neighborhood of 15 to 20 pounds, a drawn steel wire capable of sustaining a shock load of say ten times this weight, (i. e., a load of 150 to 200 pounds) need only be approximately .0005 or .0006 of an inch in diameter. Assuming the shell which I have illustrated in the drawings to be of 90 mm. caliber and of conventional length, the size of the reel of wire shown therein would contain several hundred feet of such wire. By devoting more space to the wire or making a slightly longer shell, a length of a few thousand feet may be coiled therein, if desired.

The total amount of wire is preferably divided into two or more reel sections 42a, 42b, etc., so as to reduce the relative rate at which the wire unwinds or separates from any one part of the total supply, after the opening of the shell. For example, having the wire unwind from two reel sections results in an unwinding rate which is only half of the unwinding rate which would be necessary if the unwinding occurred solely from one reel section. This reduces the strain on the wire and on the parachute following the opening of the shell. The coils of wire are preferably impregnated or embedded in resin, pitch, rubber or other suitable material 218 which will offer substantial resistance to the unwinding of the wire from the reel sections. This material 218 is flowed in a molten or fluid state into the interstices between the convolutions of wire in the winding of the reel sections, or immediately thereafter, so that when said material solidifies it holds all of the turns of wire in an adherent mass, whereby the reel sections can be stored or assembled into the shells as substantially rigid units. Furthermore, such material exerts a continuous retarding or braking effect on the unwinding of the wire, so as to slow down the velocity of the front section 31a of the shell as rapidly as possible, after the shell has been parted into its two sentions. The quick slowing down of the front shell section 31a reduces the shock which is imposed on the parachute 41 at the instant that the latter is withdrawn from the rear shell section and first receives the full impact of the air stream, this quick reduction in velocity minimizing the possibility of tearing or disrupting the parachute in the event that the shell is timed to open at a relatively low altitude where its normal velocity is very high. Instantly upon opening of the shell, the rear shell section 31b decelerates at a more rapid rate than the front shell section because of its greater air resistance and lesser mass, and in consequence the intervening span of wire starts tearing loose from the rear end of the front reel section 42a and from the front end of the rear reel section 42b. Each of these reel sections is preferably secured in its respective shell section 31a and 31b by an adhesive, or by a force fit, or in any other suitable manner; and if desired, they may be enclosed within cardboard or like containers before being secured in their respective shell sections. In Figure 2, the end walls 221 are illustrative of such containers or of cardboard spacers. The projection of the trigger assemblies 51 into their outward, cocked positions presents an area of very large wind resistance at the rear end of the front shell section 31a, and this aids in rapidly decelerating said front shell section.

It may be desirable to delay the ejection of the parachute 41 from the rear shell section 31b to insure that the shell sections have been slowed down to velocities which will not tear or disrupt the parachute. This may be accomplished by making the rear reel section 42b function as a plug for retaining the parachute in place until substantially all of the wire of said plug has been unwound. To this end, said wire plug is wound to form an outer retainer flange which engages in back of the abutment ring 181. In assembly, the parachute is packed in place and the wire plug 42b is then packed in front of the chute, following which the abutment ring 181 is screwed in along the thread 182 to retain the chute and wire in place. According to this arrangement, practically all of the convolutions of wire must be pulled loose from the resin or other matrix material 218 in the plug 42b before the parachute can be drawn out of the rear shell section. Owing to the conical shape of said wire plug, extending back into the front end of the packed chute, the unwinding of the plug leaves the front portion of the chute free to contract sufficiently to slip past the abutment ring 181. In lieu of the above arrangement, the chute can be arranged for release or ejection almost immediately upon the opening of the shell, if desired. Of course, the front end of the wire in front reel section 42a is anchored to the head 137 on the outer end of the spring rod 134, and the rear end of the wire in rear reel section 42b is anchored to the shroud lines of the parachute.

The invention embraces several instrumentalities to cushion the jerk or shock on the wire when struck by a high speed airplane traveling in a more or less horizontal flight path. The long range of yield of the spring rod 134 constitutes one of these instrumentalities. Also, the fact that the steel wire 42 has remained in a tightly wound

reel for a substantial time results in long spiral convolutions remaining in the wire even when suspending the front shell section from the parachute, these long spirals affording a considerable range of elastic deflection in the wire. In addition, the elasticity inherent in several hundred feet of steel wire is considerable. As a still further instrumentality to absorb shock, I also contemplate constructing the parachute **41** so that there will be increased venting, slipping or spilling of the air from the parachute until the shock or extremely high relative velocity has been absorbed. Figure 24 shows a parachute having an expansible vent **231'** obtained by employing elastic upper gussets **232** which yield under abnormally high air pressures and increase the effective area of the vent **231'** in the top of the chute. These gussets may be composed of rubberized fabric, sheet rubber, or any other thin, light elastic material suitable for such use. As the parachute starts slipping back with reference to the forward motion of the plane, thereby drawing the explosive section of the shell toward the plane, the expansible vent **231'** diminishes in area for increasing the drag of the parachute.

In Figure 25 I show another embodiment of parachute in which the shroud lines **235** at one side are substantially non-elastic, while the shroud lines **237** at the other side, or over a limited segment of the parachute, are quite elastic under high tension stresses. Hence, a sharp jerk or an extremely high velocity imposed on the parachute for a brief interval will cause the elastic shroud lines **237** to yield for permitting one side of the chute to spill the air and reduce the pressure, such being illustrated by the change from the dotted line position to the full line position. The elasticity of the successive shroud lines **237** may be graduated to result in an even or graduated segment of the chute performing this spilling function. As the velocity of the parachute diminishes this spilling of the air also diminishes, until the chute resumes its normal shape. Such spilling of the air from the chute tends to cause it to travel sidewise, and at such times it is desirable that this sidewise travel be in a direction such as to keep the wire **42** drawn down tight across the top of the airplane wing. One expedient helpful in this regard is to provide a weight **239** or to otherwise weight that side of the parachute which has the non-elastic shroud lines **235** so that this side will usually be lowermost, and hence the sidewise slipping of the chute will be in a downward direction.

In Figure 26 I have illustrated another construction of yieldable parachute in which there is provided an inner set of non-elastic shroud lines **241** secured to an inner circular portion **243** of the chute, and an outer set of elastic shroud lines **245** secured to the outer edge of the chute. If desired, the inner circular portion may be defined by a circular reenforcing cord **243** sewed or woven into the fabric, with the inner set of non-elastic shroud lines fastened to said cord. It will be evident that an abnormally high air pressure can telescope the outer portion of the parachute, i. e. from the dotted line position to the full line position, but that the inner portion of the parachute will remain effective by virtue of the non-elastic shroud lines **241**. As the velocity diminishes the outer elastic shroud lines **245** keep pulling the outer portion of the chute forwardly until finally the chute resumes its normal shape, indicated in dotted lines. It will be evident that each of the foregoing parachute constructions will readily yield and assume a condition of reduced drag in response to a sharp jerk or a sudden high velocity, thereby minimizing the shock load stresses in the parachute, wire and shell. As previously remarked, the parachute is made as invisible as possible to enemy aircraft, either by constructing it of a very translucent material, or by coloring it with a very inconspicuous or camouflaging color. For the purpose of enabling ground observers to spot the parachute shells at high altitudes so as to calculate wind velocities and direction of drift, some of the parachutes may have prominent color bands, segments or other markings; and, if desired these markings may be applied only to the undersurfaces of opaque parachutes so as to be invisible to enemy planes from the side or from above. These marked parachute shells would be fired only at spaced time intervals for observing wind velocities and the direction of drift at the altitudes where the shells are expected to be most effective against enemy aircraft. With regard to the area of each parachute, this may vary from approximately 20 square feet to 50 square feet and upwards, depending upon the size of the shell, the amount of space therein reserved for the parachute, etc. The length of the shell casing shown is standard practice for timed high explosive shells of 90 mm. caliber, but where the guns, caissons and other equipment permit the use of a longer shell a greater volume of the shell may be devoted to the parachute. Too large a parachute may be undesirable in some instances because of the long delay in the descending parachute shell reaching the ground and the considerable distance that such shells might drift in a high wind. These drifting parachute shells are potential hazards against all defense planes as well as enemy planes and it may therefore be desirable that the parachute shells descend to the ground within a reasonably short time.

In Figure 27 I have illustrated a modified arrangement in which the rear shell section **31***b* is not dropped to the ground upon the opening of the shell, but instead is held suspended from the parachute wire **42**. In such an arrangement, a separate suspension wire **247** has one end anchored to the shell section **31***b*, and has its other end anchored at **249** to the parachute wire **42**. This separate wire is secured to the interior of the shell section, preferably at the inner end thereof, and is then led around the outside of the parachute in the packing of the latter into said interior. The particular location of the point of anchorage **249** along the main wire **42** may vary, depending upon the requirements of the particular embodiment. Several advantages are obtained by this general arrangement. First, there would be a much higher percentage of recovery of all parts of the parachute shell for future use because the rear shell section would always remain with the parachute and wire, even in the case of parachute shells which had been detonated by contact with airplanes, secondly, these rear shell sections are quite heavy and a large number of them falling in an intensive barrage might do substantial damage to buildings and ground personnel. Furthermore, and possibly of greatest importance, the considerable weight or mass of this rear shell section may be utilized to balance or compensate the shock stress set up at the other end of the steel wire by the relatively large mass of the front shell section **31***a*. When an airplane strikes the wire with considerable shock, the parachute itself affords a very small mass of inertia

at the upper end of the wire, whereas the front shell section **31***a* affords a considerable mass of inertia at the lower end of the wire. Hence, during this initial period of impact and high shock load there may be a tendency for the wire to run toward the shell section **31***a* instead of toward the parachute **41**. However, by having the rear shell section **31***b* remain suspended from the parachute wire, preferably at a point adjacent to the parachute, a substantial mass is made effective at the upper end of the wire for balancing a considerable part of the mass at the lower end of the wire, whereby the parachute becomes effective more quickly for causing the wire to run toward the parachute and draw the explosive section **31***a* into firing contact with the airplane. In any entangling of the wire **42** in or around an airplane, the mass of this rear shell section **31***b* also aids in establishing and maintaining such entangled relation.

Referring now to Figures 28, 29 and 30 which show a modified arrangement using grappling hooks and grappling wires so as to minimize the possibility of the parachute wire **42** slipping laterally off the end of an airplane wing, the grappling hooks **253** each consist of a plurality of grab hooks or prongs, preferably three or four in number, and radiating outwardly from a cluster, much in the manner of a gang type of fishhook. The several prongs of such a grappling hook may be proportioned and arranged to fit over or across either or both reel sections **42***a* and **42***b*, or they may be of articulated construction so that they will fold into a very small space in the shell. This grappling hook is anchored to the lower end of a grapping wire **255** which is of approximately the same gauge or lighter than the parachute wire **42** and which is suitably wound with the parachute wire or disclosed between the reel sections thereof when assembled into the shell. Instead of a wire, this grappling strand **255** may be a twine cord or the like. Said grappling wire or cord does not need to be very long; in the representative construction illustrated its length is approximately twice the chord of a typical airplane wing. The attachment of the grappling wire to the parachute wire is through a sliding friction tube **257**. The grappling wire is fixedly anchored to said tube, and the tube has a tightly engaging slide fit along the parachute wire **42**. Instead of the tube **257**, a tightly engaging slidable ring may be employed. Only one of said grappling hooks and wires may be provided, mounted on the parachute wire approximately midway of its length; or two or more of said grappling hooks and wires may be provided, spaced equal distances from each other and from the ends of the wire or in any other desired relation. The theory of operation is that each grappling hook **253** will have a whipping action at the end of its grappling wire or cord **255** so that if one of these grappling hooks is rapidly drawn up to the under side of the plane wing and around the front edge of the wing, under the action of the parachute jerking the upper run of the main suspension wire **42** backwardly, there will be a decided likelihood of the grappling hook **253** becoming caught over the trailing edge of the wing structure, as shown in Figure 29. This trailing edge usually comprises ailerons, landing flaps and various other devices that form notches, projections or the like which would catch the grappling hook and prevent it from slipping outwardly toward the top of the wing. Thus, the grappling wire **255** and the guide sleeve **257** would be prevented from sliding outwardly, even if the sweep-back angle at the leading edge of the wing tended to deflect the main suspension wire **42** toward the tip of the wing. Although the guide sleeve **257** would thus hold the suspension wire from shifting outwardly, nevertheless the suspension wire could be drawn through the sleeve, and hence the parachute could pull the explosive shell section **31***a* up into firing contact with the airplane in the same manner as described before. If desired, a small stop bead **259** may be crimped or otherwise rigidly fastened to the suspension wire **42** to function as a limiting stop to be engaged by the upper end of the slidable guide sleeve **257**, as clearly shown in Figure 30. This stop bead would prevent any possible reverse running of the suspension wire **42** toward the shell section **31***a* after the grappling hook and grappling wire had snagged the trailing edge of the wing, as by slipping across the top of the wing instead of across the under side thereof. If the main wire is equipped with two or more grappling hooks and grappling wires, there would still be only one stop bead and this would be secured to the suspension wire at a point above the uppermost guide sleeve **257**. It will be understood that the stop bead **259** is entirely optional, and that this is also true of the grappling hooks and grappling wire.

Figure 29 illustrates in dash and dot lines how any projection, notch or shoulder extending from the leading edge of the airplane wing or fuselage will serve to stop the suspension wire from sliding off the end of the wing. The projection *m* is intended to represent a wing type of machine gun.

While the suspension member **42** which suspends the shell section from the parachute is preferably a steel wire of circular cross-section, the invention is not limited to the use of this material or to this shape of suspension member. For example, it is conceivable that the suspension member might be in the form of a very thin ribbon or tape **42***t*, as shown in Figure 31. This would preferably consist of other materials. The advantage of a tape over a circular wire would be that the flat width of the tape would afford a bearing area of substantial width across the front edge of the airplane wing, so that there would be much less likelihood of the tape cutting into the front edge of the wing than in the case of a circular wire. This advantage would be predicated on the assumption that a free running suspension member **42** or **42***t* would be desired for drawing the shell section **31***a* into firing contact with the airplane, rather than a cutting member for cutting into the airplane wing. If grappling hooks are used in such embodiment, the guide sleeve or ring **257'** is shaped like the metallic tape **42***t*.

In the embodiment shown in Figures 1 to 4 inclusive, the slots **172** in the sleeve extension **145** have their rear ends formed as right angle shoulders **172***b* adapted to effect a positively hooked engagement with the shouldered ends **171'** of the sprung fingers **171**, whereby the inertia shock set up in the shell by a high speed airplane striking the suspension wire **42** along a substantial horizontal flight path cannot jar the sleeve **145** and percussion plunger **76** forwardly or downwardly into firing engagement with the primer **75**. In such embodiment, the firing of the primer **75** requires that the trigger mechanism **51** be tripped by contact with the airplane. While this

construction is the preferred embodiment, my invention also contemplates as an alternative construction an arrangement in which a relatively high or predetermined impact force transmitted through the suspension wire to the shell section can fire the primer and detonate the shell section without having to trip the trigger mechanism 51. Such modified embodiment is obtained by merely forming the rear end of each slot 172 with a gradual slope 172c, as shown in Figure 13, instead of with a right angle shoulder. These sloping rear ends 172c are inclined at an angle which is calculated to let the sleeve extension 145 and plunger 76 jump forwardly into firing engagement with the primer under the action of inertia, when an extremely heavy impact shock is transmitted through the suspension wire to the shell section. The shifter spring 126 may be substituted by a lighter or heavier spring, which can be proportioned with respect to different angles of the rear slope 172c so as to produce any desired degree of sensitivity of the plunger 76 to firing by inertia shock transmitted through the suspension wire. For a maximum degree of sensitivity, the extension sleeve 145 could have its rear end terminating at the front shoulders 172a, and the spring 126 could be very light. This manner of firing the shell section by impact shock through the wire might be employed advantageously when using a relatively short length of wire. The theory of operation would be that because of the shortness of the wire the shell section would necessarily be in close proximity to any airplane striking the wire, and hence the detonation of the shell section immediately upon the airplane striking the wire would produce effective results. Some of this firing sensitivity to impact shock through the wire might be incorporated in constructions using a long length of wire. An airplane striking the wire at an elevated point near the parachute will not cause near as much impact shock at the shell section as will an airplane striking the wire at a low point near the shell section. The firing sensitivity may be proportioned so that the relatively smaller impact shock at the shell section resulting from the airplane striking the upper portion of the wire will not fire the shell section, but the greater impact shock resulting from the airplane striking the wire in proximity to the shell section will detonate the latter. This sensitive type of firing apparatus might also be adapted to a shrapnel type of projectile where the shrapnel balls would be fired from the open rear of the front shell section 31a toward the airplane. For example in the construction illustrated it would be possible to make the wall 54 rather weak and to dispose same sharpnel balls on the inner side of said wall to be blown upwardly with the wall toward the airplane.

Figures 32 and 33 illustrate an optional feature which may be incorporated in or associated with the third powder train ring 103 if desired. This feature is that of being able to convert the shell into a timed high explosive shell, as previously referred to in the description of said ring. When the ring 103 is constructed to have this convertible feature, it is formed with two angularly spaced grooves 265 and 266 in its front face. These grooves are preferably in diametrically opposite relation, and may be flash passages or may be packed with black powder or any other suitable igniting material. Such material has not been shown to avoid obscuring the illustrations. Figure 32 illustrates the ring in its normal position, in which position the groove 265 connects the time train 44 with the detonator 67 for releasing the parachute at the predetermined altitude. In this position, the other groove 266 merely stands idle, the primer 75 remaining connected with the booster charge 72 through passages 121, 122, 109, and 74 for exploding the shell should the primer be fired. In this normal position of the ring, the lower end of the groove 265 registers with the transfer port 106 which is formed in the stationary spacing ring 102, and through which port the ignition of the time train rings 92 and 93 is transferred to the groove 265. The upper end of said groove is formed with a rearwardly facing port 108 which registers at this time with a port 68' opening into the detonator 67. The other groove 266 is performing no function in this position of the ring 103. As previously described, the primer thimble 116 has a plurality of radially extending ports 121, all of which can fire in a forward venting direction beyond the forward edge of the ring 118 when the thimble is in its forward safety position. When the thimble is in its rearward firing position, that group of the ports 121 shown as being lowermost registers with a cooperating series of stationary ports 122 which extend outwardly through the ring 118 and sleeve 84 and open into the right angle ports 109. As shown in Figure 2, these right angle ports 109 are adapted to fire through passageways 74 which open into the booster charge 72. Thus, in the normal position of the converting ring 102, the time train is operative to open the shell for ejecting the parachute, and the primer 75 is operative to fire the booster charge 72 and explode the shell. Also, it will be noted that in this position of the apparatus the primer is capable of exploding the shell either upon direct percussion of the shell against an airplane before ejection of the parachute, or upon tripping of the trigger mechanism 51 against an airplane after ejection of the parachute.

Figure 33 illustrates the transposed position of the grooves 265 and 266 when the ring 103 has been turned through 90° in a clockwise direction to a position which converts the shell into a timed high explosive projectile. In this position of the ring, the groove 265 stands idle, no communication being established from the time train to the port 68' and detonator 67, and hence there is no timed opening of the shell for the ejection of the parachute and wire. However, the other groove 266 now occupies an effective position for establishing communication from the time train to the right angle ports 109 and passageways 74 and thence to the booster charge 72 for firing the high explosive charge 43. The lower end of the groove 266 is permanently connected with one or more of the right angle ports 109, and when the ring is in this converting position these ports register with corresponding passageways that lead to the booster charge 72. The upper end of said groove is then in registration with the port 106 in the stationary ring 102, whereby the time train fires through the groove 266 for exploding the shell after the lapse of a set time interval. This optional feature enables the shell to be instantly converted from the parachute type to the conventional timed high explosive type. This would enable different types of antiaircraft fire to be carried on without the necessity of providing the gun with more than one type of projectile. When the shell is thus converted to timed high explosive operation, the

percussion plunger 76 still is responsive to impact and hence in the event of percussion contact of the shell the primer 75 will fire through the ports 121, 122, 109 and 74 for exploding the shell in the same manner as described of percussion detonation when the ring 103 is in its normal position (Figure 32) for normal parachute operation of the shell. The percussion detonation feature is of advantage against low flying aircraft when the chances of a direct hit are greatly increased. This feature also enables the shells to be used effectively in emergency situations, such as against tanks, ground personnel, etc.

The converting ring 103 is also movable to still another position where it functions as a safety ring. This safety position is between the two positions shown in Figures 32 and 33, and with the right angle ports 109 out of registry with the passages 122. In this safety position neither of the two arcuate grooves 256 or 266 is in registry with the transfer port 106. Also, with the right angle ports 109 out of registry with the passages 122, any accidental firing of the primer 75 cannot be transmitted on to the booster charge 72. The ring 103 can be retained in this safety position during all transporting and handling of the shell.

In reviewing the various features of my invention, it will be apparent that many features are adaptable to other types of antiaircraft devices not limited to shells. For example, many features could be embodied in parachute suspended high explosive devices which might be dropped from an airplane for use at a lower level, instead of being fired to this level from an antiaircraft gun. Thus, the assemblies shown in Figures 19, 20, 21, 22, 23, 27, 28, and 29 may be dropped from an airplane as complete units cocked to be detonated by impact from another airplane.

While I have illustrated and described what I regard to be preferred embodiments of my invention, nevertheless it will be understood that such are merely exemplary and that numerous modifications and rearrangements may be made therein without departing from the essence of the invention. In this regard, it will be understood that many of the constructions which I have referred to as alternative or modified constructions can be embodied in various combinations in the preferred or main construction. For example, this main construction might include all or any number of the arrangements illustrated in Figures 12, 13, 24, 25, 26, 27, 28, 29, 30, 31, 32, and 33.

I claim:

1. In an antiaircraft shell adapted to be fired from a gun, the combination of front and rear shell sections adapted to be separated while the shell is in flight, a time fuse in said front section, an opening charge adapted to be ignited by said time fuse, a piston member actuated by said opening charge for separating said shell sections, said piston member remaining with said front shell section after the separation of said shell sections, trigger mechanism carried by said piston member and movable to cocked position at the rear end of said front section upon the separation of said sections, a parachute and a length of wire released from said shell upon the separation of said sections, said wire thereupon hanging from said parachute and the front section of said shell hanging from said wire, a high explosive charge in said front shell section, and means responsive to the tripping of said trigger mechanism for firing said high explosive charge.

2. In an antiaircraft shell adapted to be fired from an antiaircraft gun, the combination of a shell casing, an explosive charge therein, a parachute in said casing, a suspension wire in said casing, means for opening said shell casing at a desired altitude and thereupon releasing said parachute and suspension wire, said wire being arranged to hang from said parachute, the explosive charge portion of said shell being arranged to hang from said wire, means for firing the explosive charge portion of said shell upon contact with an airplane, a guide member having sliding engagement along said suspension wire, a stop carried by said suspension wire for limiting sliding movement of said guide member along said wire in one direction, a grappling wire attached to said guide member, and a grappling hook at the end of said grappling wire adapted to hook over the trailing edge of the wing or other portion of the airplane for preventing said suspension wire from slipping off the end of the airplane wing.

3. In an antiaircraft shell adapted to be fired from an antiaircraft gun, the combination of a shell casing comprising front and rear sections, a charge of high explosive in said front section, a tubular stem extending through said charge of high explosive, a time fuse in the nose of said shell, an opening charge of powder at the rear of said front shell section adapted to be ignited by said time fuse through said tubular stem at a predetermined altitude, an opening piston at the rear of said front shell section responding to said opening charge and serving to open said shell by separating said front and rear shell sections, a firing spring in said tubular stem placed in cocked condition by the opening movement of said piston, trigger devices associated with said piston and movable into cocked position by the opening movement of said piston, a parachute and a reel of wire contained within said shell and released therefrom upon the separation of said shell sections, means for delaying the opening of said parachute, said wire thereupon hanging from said parachute and said front shell section hanging from said wire, whereby said parachute and wire tend to draw said front shell section toward any airplane intercepting said wire, said trigger devices being releasable by impact against an airplane in a direction either longitudinally or laterally of said front shell section, a firing plunger urged forwardly by said firing spring and tripped for such forward movement by the releasing of said trigger devices, a primer adapted to be fired by said firing plunger for detonating said charge of high explosive, said primer being shiftable between a normal firing position and a safety non-firing position, the movement of said primer into said safety non-firing position being in a direction tending to prevent said firing plunger reaching said primer, a pair of ports maintained in registry for conducting the flash of said primer toward said charge of high explosive when said primer is in its normal position, said ports moving out of registry when said primer shifts to its safety position, a shifter spring tending to shift said primer into said safety position, releasable means for opposing said shifter spring during the flight of the shell and until the opening thereof, and a suspension spring connecting said wire with said front shell section and arranged to hold said primer in its normal firing position so long as the weight of said shell section is suspended from said wire, but permitting said primer to move to its safety position when the weight of said

front shell section is taken off the wire by striking the ground.

4. In an antiaircraft shell adapted to be fired from a gun, the combination of a shell casing comprising front and rear shell sections, a charge of high explosive in said front shell section, time responsive means carried by said shell for parting said shell sections at a desired altitude, a parachute and a substantial length of wire released from said shell upon the parting of said sections, said wire being coiled in a plurality of reel sections with the successive convolutions releasably bound together in a matrix of yieldable material, whereby the unwinding of the wire from said matrix imposes a braking retardation on said front shell section, said wire thereafter hanging down from said parachute and said front shell section hanging from said wire, trigger mechanism carried by said front shell section and moved to cocked position in the parting of said shell sections, said trigger mechanism comprising front and rear shiftable members shiftable axially relatively to each other and to said front shell section, a firing spring carried by said front shell section tending to move said front shiftable member forwardly, secondary spring means carried by said front shell section tending to hold said shiftable members in axially separated relation, a set of front links carried by said front shiftable member, a set of rear links carried by said rear shiftable member and pivotally connected with said front links, said two sets of links coacting to form collapsible struts bearing against the rear edge of said front shell section when said trigger mechanism is in its cocked position, said trigger mechanism being trippable by impact acting in either a longitudinal or lateral direction with respect to said front shell section, a firing plunger carried by said front shell section and adapted to be actuated by the tripping of said trigger mechanism, and detonating means carried by said front shell section and fired by said plunger for detonating said charge of high explosive.

5. An antiaircraft shell adapted to be fired from a gun, the combination of a shell casing, a charge of high explosive in one portion of said casing, a parachute and a wire in said casing, means for releasing said parachute and wire from the shell at a desired altitude, said wire thereupon hanging from said parachute and the explosive containing section of said shell hanging suspended from said wire, a centrifugally armed firing plunger in the latter suspended section of said shell, trigger means carried by said suspended shell section and operatively connected with said firing plunger for releasing said firing plunger upon contact with an airplane, a primer in said suspended shell section adapted to be fired by said firing plunger upon contact of said trigger means with an airplane for detonating said high explosive, said primer being movable between an operative firing position and an inoperative or safety position, means connected with said primer for retaining said primer in its operative firing position so long as the explosive containing section of said shell is suspended in the air, but causing said primer to move to its safety position when the latter section of said shell engages the ground, and a manually settable ring adapted to be set before the firing of the shell and remaining with said suspended shell section for controlling the firing communication between said primer and said high explosive charge.

6. In an antiaircraft shell adapted to be fired from a gun, mortar or the like, the combination of shell sections capable of being separated while the shell is in flight, a separating charge for separating said sections, a time fuse for firing said separating charge, a parachute and a length of wire released from said shell upon the separation of said sections, said wire thereupon hanging from said parachute and a section of said shell hanging suspended from said wire, a high explosive charge in said latter shell section, firing means for firing said high explosive charge including trigger means mounted on shiftable pivots carried by said suspended shell section so as to be trippable by impact against an airplane acting in either a longitudinal or lateral direction with respect to said suspended shell section, means carried by said latter shell section for retaining said firing means inoperative during the discharge of the shell from said gun, mortar or the like and for rendering said firing means operative after said shell sections have separated, and means carried by said suspended shell section and responsive to the weight of said shell section being taken off said wire when said parachute suspended shell section drifts down and strikes the ground for thereupon rendering said firing means inoperative.

7. In an antiaircraft shell of the class described, the combination of a parent shell adapted to be fired from a gun, mortar or the like, said parent shell comprising front and rear shell sections constituting structural parts of the parent shell, an opening charge of powder for separating said shell sections, timing means for effecting a time delayed firing of said opening charge at a point in the trajectory of the parent shell, an opening piston movable relatively to said front shell section and responding to the firing of said opening charge for separating said shell sections, said opening piston remaining with said front shell section after the separation of said sections, a coil of wire in rear of said piston, a parachute in rear of said coil of wire, said parachute and wire being ejected from said parent shell upon the separation of said shell sections, said wire being connected to thereupon suspend said front shell section from said parachute, a high explosive charge in said front shell section, and firing means for firing said high explosive charge comprising trigger means connected with said opening piston and adapted to be placed in cocked position against the rear end of said front shell section, said trigger means being tripped by contact with an airplane.

8. In an antiaircraft shell of the class described, the combination of a parent shell adapted to be fired from a gun, mortar or the like, said parent shell comprising front and rear shell sections constituting structural parts of the parent shell, an opening charge of powder for separating said shell sections, timing means for effecting a time delayed firing of said opening charge at a point in the trajectory of the parent shell, an opening piston responding to the firing of said opening charge for separating said shell sections, a coil of wire in rear of said piston, a parachute in rear of said coil of wire, said parachute and wire being ejected from said parent shell upon the separation of said shell sections, said wire being connected to thereupon suspend said front shell section from said parachute, means for holding said rear shell section attached to said wire at a point adjacent to said parachute after the separation of said shell sections, a high explosive charge in said front shell section, and fir-

ing means for firing said high explosive charge comprising trigger means connected with said opening piston and adapted to be placed in cocked position against the rear end of said front shell section, said trigger means being tripped by contact with an airplane.

9. In an aerial mine comprising a parachute, a suspension wire and an explosive charge suspended from said parachute by said wire and adapted to be detonated when said mine is struck by an airplane, the combination therewith of a guide member having sliding engagement along said suspension wire, a stop carried by said suspension wire for limiting sliding movement of said guide member along said wire in one direction, a grappling wire attached to said guide member, and a grappling hook at the end of said grappling wire adapted to hook over the trailing edge of the wing or other portion of the airplane for preventing said suspension wire from slipping off the end of the airplane wing.

10. In an aerial mine comprising a parachute, a suspension wire, and an explosive charge suspended from said parachute by said wire and adapted to be detonated when said mine is struck

by an airplane, the combination therewith of a guide member having sliding engagement along said suspension wire, a flexible grappling strand attached to said guide member, and a grappling hook at the end of said flexible grappling strand adapted to hook over the trailing edge of the wing or other portion of the airplane for preventing said suspension wire from slipping off the end of the airplane wing.

11. In an antiaircraft shell adapted to be fired from a gun, mortar or the like and to open while in flight to release an aerial mine comprising a parachute, a suspension wire and an explosive containing portion of said shell suspended from said parachute by said wire, the combination therewith of a guide member having sliding engagement along said suspension wire, a grappling strand attached to said guide member, and a grappling hook at the end of said grappling strand adapted to hook over the trailing edge of the wing or other portion of the airplane for preventing said suspension wire from slipping off the end of the airplane wing.

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