

[54] DISCARDING SABOT PROJECTILES

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[*] Notice: The portion of the term of this patent subsequent to Feb. 6, 1990, has been disclaimed.

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Related U.S. Application Data

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[52] U.S. Cl. 102/93

[51] Int. Cl.² F42B 13/16

[58] Field of Search 102/52, 93, 94, 92.2, 92.3, 102/92.4

[56] References Cited

UNITED STATES PATENTS

3,714,900 2/1973 Feldmann 102/93

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[57] ABSTRACT

A discarding sabot projectile of novel construction is provided whereby separation of the components is accomplished by the combined effect of centrifugal force and the impingement of muzzle gases from the exhausting gun barrel. The sabot preferably comprises a metallic base incorporating means to impart spin to the projectile, and a plastic body firmly surrounding and supporting a sub-caliber core so that the longitudinal axis of the sub-caliber core is coincident with the axis of the full caliber projectile. The plastic body includes a plurality of longitudinally extending slots, or similar weakening lines, beginning at the rear of the plastic body and extending forward toward the tapered nose. Immediately after discharge from the muzzle, the sabot body starts to separate into symmetrical segments, beginning at the rear of the body, under the centrifugal force of projectile spin. The further opening of the body, which progresses along the weakened lines toward the nose, is such that the body segments are struck by the expanding muzzle gas which, in combination with the centrifugal force of spin, effects final separation and dispersal of body components. Projectile separation as described results in minimized muzzle velocity decay and dispersing effects on the sub-caliber core. Exterior configuration of the projectile is uniquely suited for automatic firing in modern, rapid-fire guns under variable environmental conditions.

3 Claims, 9 Drawing Figures

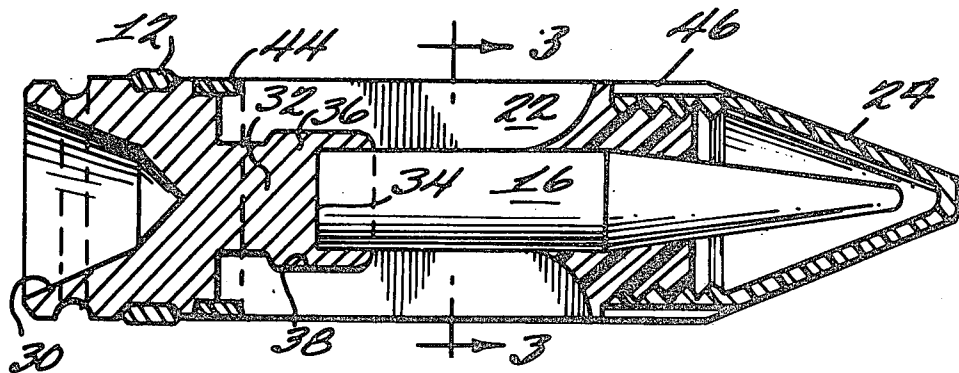


Fig. 1

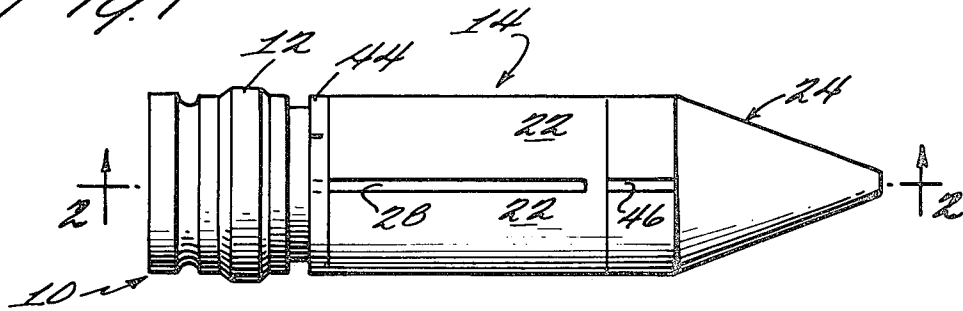


Fig. 2

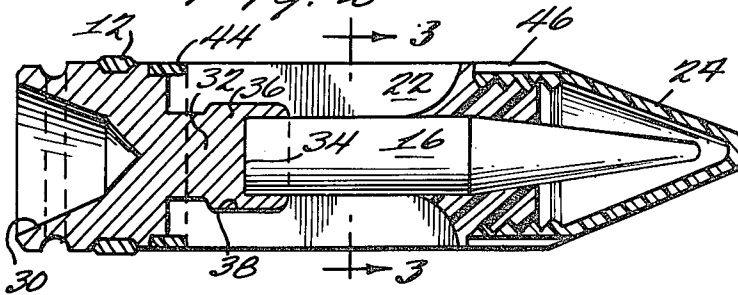
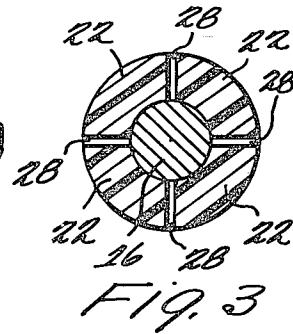


Fig. 3

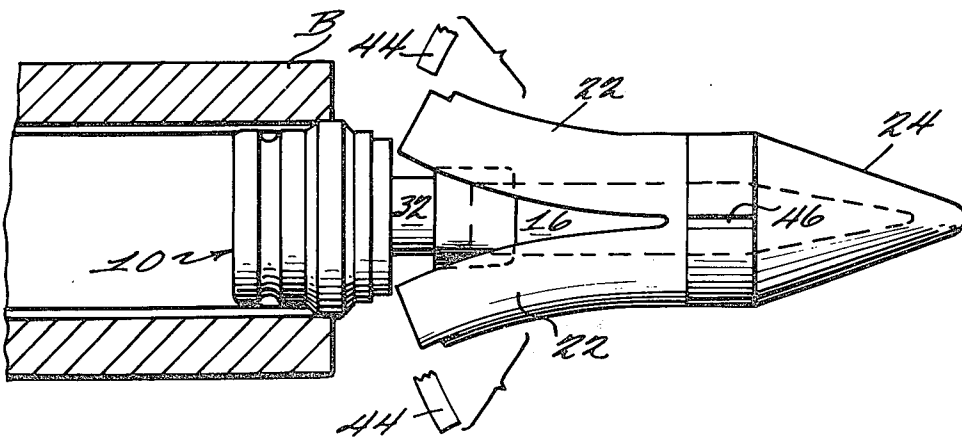
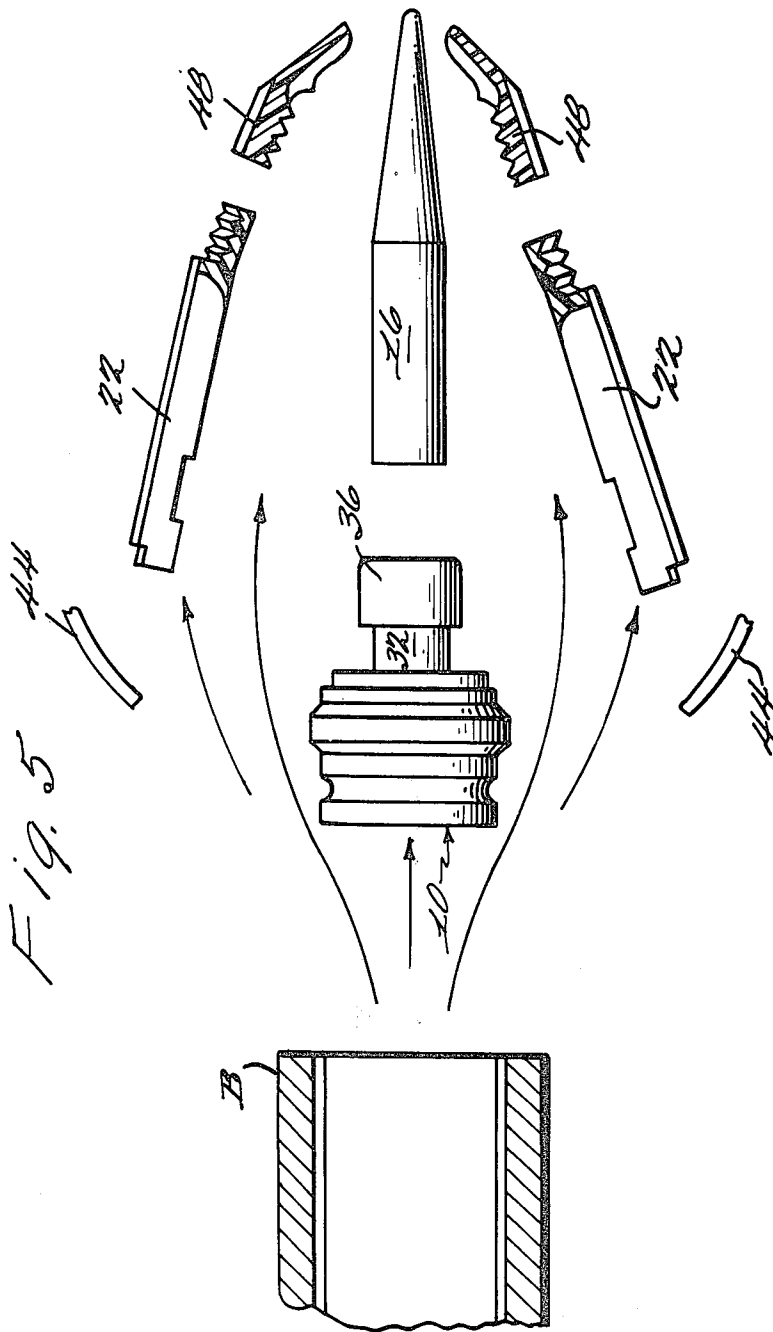
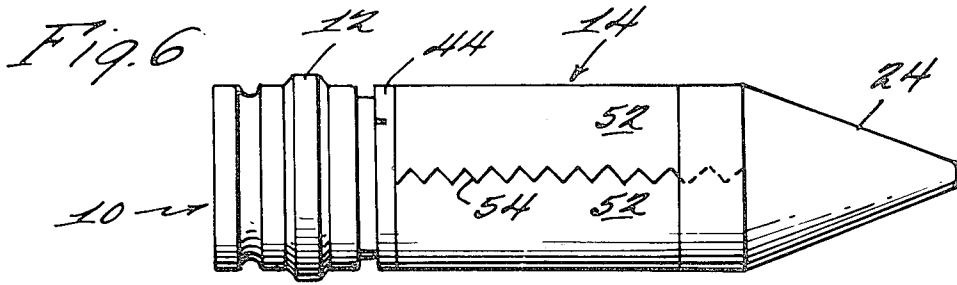
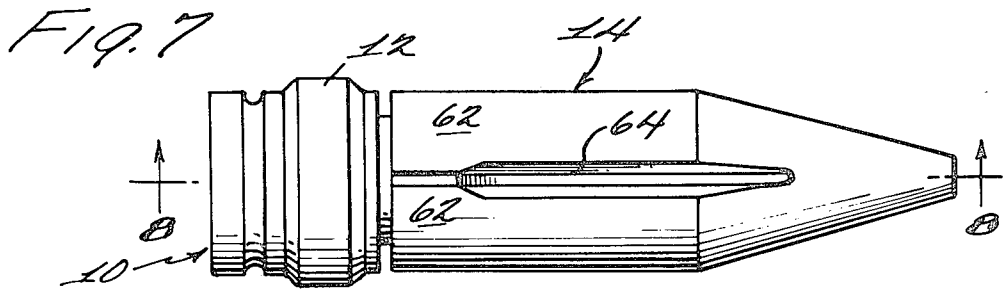
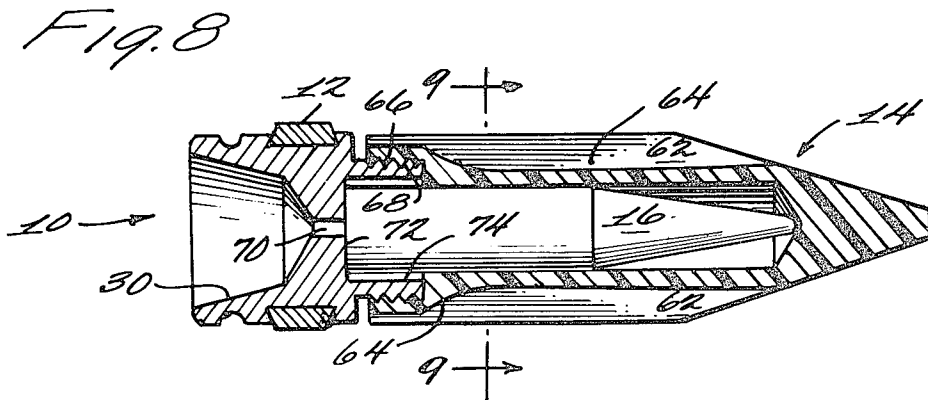
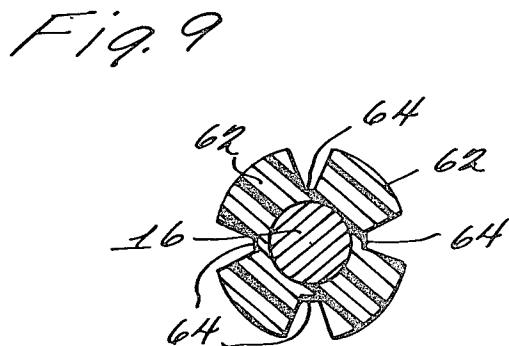


Fig. 4





DISCARDING SABOT PROJECTILES

This application is a continuation of application Ser. No. 278,859 filed Aug. 8, 1972, now U.S. Pat. No. 3,847,082, which is a continuation of application Ser. No. 854,095 filed Aug. 29, 1969, now U.S. Pat. No. 3,714,900 granted Feb. 6, 1973.

This invention relates to projectiles for guns and rifles and, more particularly, to discarding sabot projectiles incorporating a sub-caliber core.

It has long been known that because of superior intermediate and terminal ballistic velocities and resulting increase in performance, a sub-caliber core discharged from a full caliber gun or rifle can penetrate and defeat heavier, or more resistant, targets than is normally possible with armor piercing ammunition of full caliber. Accordingly, considerable efforts have been devoted in the past to the development of a variety of types of discarding sabots to serve as the launching means for such sub-caliber cores. While in many instances superior penetration performances have been realized to some extent, the discarding sabot projectiles heretofore known have not been completely satisfactory. These projectiles have shown inherent disadvantages which either retarded the realization of their full armor penetrating potential, or which induced or accentuated other undesirable characteristics, which do not ordinarily materially affect the performance of conventional full caliber projectiles. These latter characteristics have included (a) reduced hitting accuracy due to non-axial, dispersing forces and moments influencing the sub-caliber core during separation from the sabot components; (b) deterioration in performance and reliability under adverse environmental conditions, particularly at extreme temperature conditions; (c) limited usefulness due to noncompatibility with the feeding and loading mechanism in conventional automatic guns and rifles; (d) added danger to friendly troops due to excessive zones of dispersal of the rapidly moving sabot components; and (e) increased production costs, attributable primarily to the requirements for exceedingly close manufacturing tolerances and the added materials and fabrication costs.

To illustrate some of the foregoing disadvantages, one such known prior discarding projectile accomplishes separation of the sabot and the sub-caliber core by differential drag forces between the former and the latter. This full caliber sabot is essentially cup shaped, having an axial bore in its forward portion, and receives the base and a considerable portion of the body of the sub-caliber core snugly within this bore. When the projectile is fired, the larger diameter of the sabot is accelerated by the gases generated and carries the sub-caliber projectile to an excellent muzzle velocity. After exit from the muzzle of the gun, greater aerodynamic drag forces act on the larger sabot than on the smaller sub-caliber core, thus causing relative axial sliding movement between the core and the sabot, until separation is achieved. If the fit between the sabot and the core is relatively tight, then, obviously, additional drag forces will be transmitted by friction from the sabot to the core, thus reducing the velocity of the core to an undesirable degree and materially defeating the primary purpose of the sabot. On the other hand, if the fit is relatively loose, the rotating sabot will not impart the proper rotation to the core, and/or the core will not be properly axially aligned, thus contributing to poor hit-

ting accuracy of the core at the target. Considering these factors, it is apparent that a very high degree of accuracy of machining, and very close tolerances, is required in such a projectile to insure acceptable performance. Nevertheless, because the core is usually desirably of a very heavy, dense metal while the sabot parts are desirably of lighter, less dense and more inexpensive materials, it is similarly apparent that despite the finest workmanship and the closest tolerance, the different coefficients of expansion of such different materials inevitably mean that the closeness of the fit will vary widely under different temperature and other environmental conditions. It will thus be readily understood that while such a projectile might perform acceptably at temperatures of 80°F., at subfreezing or elevated temperatures, the fit may be too close or too loose to permit proper performance. On the one hand, increased tolerances tend to increase the core dispersion and reduce hitting accuracy. On the other hand, decreased tolerances give rise to a detrimental projectile deceleration which is largely self-defeating. As a result, the projectile accuracy and penetration performance over the desired operational temperature range of from -65°F. to 125°F., varies considerably.

To overcome the many objections and disadvantages of the above-mentioned type of projectile, it has also previously been proposed to accomplish separation of the sub-caliber core from the sabot components through the combination of aerodynamic and centrifugal forces, the latter produced by the normal spin injected to the projectile while moving through the gun barrel. In a typical projectile of this type, the sabot components radially surrounding the sub-caliber core are in the form of petals which separate radially from the core after exit from the muzzle under the combined action of the centrifugal forces just mentioned and the retarding aerodynamic action of the surrounding atmosphere. For example, it has been proposed that the leading edges of each petal have an axially inclined surface which catches in the air stream and propels the leading edge of the petal outwardly away from the core. It has been determined, however, that separation of this type of projectile tends to introduce dispersions and undesirable projectile deceleration, and thus, this projectile is also subject to some of the disadvantages discussed previously in detail. In addition, many such projectiles suffer the additional disadvantage that they are not readily adaptable to the rapid or automatic firing of which modern conventional weapons are capable.

Accordingly, it is an object of the present invention to provide a projectile sabot assembly which overcomes to a degree heretofore unrealized, the disadvantages of prior sabot projectiles, providing penetration performance greatly superior to conventional armor piercing projectiles.

It is a further object of this invention to provide an efficient and effective sub-caliber armor piercing projectile adaptable for single or automatic firing from conventional guns and artillery.

It is a further object of this invention to provide a sabot projectile wherein the separation of the sub-caliber core from the full-caliber components results in minimum launch dispersion without inducing a significant velocity decay to the sub-caliber core, other than the normal aerodynamic drag forces acting on the core.

It is a still further object of this invention to provide a novel spin stabilized, discarding sabot projectile of

improved effectiveness, which projectile is easily manufactured, and is readily adaptable to use in conventional weapons under a wide variety of environmental conditions and loads, without substantial variation in performance.

To accomplish these and other objects of the present invention, I provide a novel sabot projectile assembly characterized by its relatively uncomplicated construction, its adaptability to use in existing single or automatic fire guns, and its adaptability to separation under the combined effects of centrifugal force and the force of impingement of the gases exiting from the muzzle, to effect a more rapid and efficient separation of the sabot components, thus maintaining maximum hitting accuracy and minimum deceleration of the sub-caliber core in flight.

A more complete understanding of the invention and of the various embodiments which the invention may take, may be gained from the following illustrative examples, and from the accompanying drawings in which;

FIG. 1 is a side elevational view of one projectile embodying the elements of the present invention.

FIG. 2 is a longitudinal sectional view, also an elevation taken along line 2—2 of FIG. 1.

FIG. 3 is a vertical cross-sectional view of the projectile of FIGS. 1 and 2 taken along line 3—3 of FIG. 2.

FIG. 4 is a further longitudinal view of the projectile of FIGS. 1 and 2, illustrating the initiation of separation of the projectile components as the projectile exits from a gun barrel.

FIG. 5 is a further longitudinal view illustrating only schematically the further dispersal of the projectile components.

FIG. 6 is another side elevational view showing a modified projectile according to this invention.

FIG. 7 is a side elevational view of another projectile, modified from that of FIG. 1, within the scope of the present invention.

FIG. 8 is a longitudinal sectional view, also in elevation, taken along line 8—8 of FIG. 7.

FIG. 9 is a vertical sectional view of the projectile of FIGS. 7 and 8 taken along line 9—9 of FIG. 8.

As shown generally in FIG. 1, a full-caliber projectile according to the present invention may have an outward shape and symmetry very similar to those of conventional projectiles, providing an advantage not heretofore obtained with most prior discarding sabot projectiles. It will be noted, however, that while the shape of this projectile is generally conventional, dissimilarities to conventional projectiles are also readily apparent. Major components or parts of this new projectile include: the sabot base (generally indicated by the numeral 10), which may be made of some light metal such as aluminum; a circular ring 12 extending circumferentially about a portion of the sabot base and preferably formed of a soft metal or a suitable plastic; the sabot body, generally indicated by the numeral 14, which may be formed of various materials but is preferably formed from a plastic having relative toughness and heat resistance; and the sub-caliber core 16 (see FIG. 2), which desirably is formed of a relatively heavy, dense metal. In the embodiment shown in FIG. 1, the sabot body is composed of two subsections, the cylindrical body 20 and the tapering nose shield 24, attached to the forward end of the cylindrical subsection.

As shown more particularly in FIG. 2 of the drawings, the sabot base 10 has a concave rearward face 30

which provides an enlarged surface against which the propelling gases may thrust. The precise shape and dimensions of this face 30 may vary, although preferably it should have the somewhat conical shape illustrated in FIG. 2. The sabot base 10 also preferably includes a forward member 32 providing a seat 34 for the base of the sub-caliber core 16. The member 32 also includes an enlarged annular portion 36 rearward of the seating surface, for reasons which will be hereinafter explained. Although the base of the sub-caliber core is intended to abut against the seat 34, the core is primarily enclosed within the annular bore of cylindrical subsection 20. The plastic wall thus defined in the cylindrical section 20 is substantially uniform in thickness and firmly encloses the sub-caliber core 16 and supports it so that the longitudinal axis of the core is aligned with the rotational axis of the full-caliber projectile. Preferably the forward interior surface 26 of the body portion is necked or tapered slightly, to approximately the same angle as the corresponding nose portion of the sub-caliber projectile, so that the section 20 firmly restrains the core 16 both from lateral movements and from forward movements beyond a pre-determined limit. The nose portion of the sub-caliber core extending through and beyond the cylindrical body wall 20 is enclosed and protected by the nose shield 24, which is attached to the forward end of the cylindrical body by means of mating threaded portions 40 and 42.

It will be noted from FIG. 3 that the cylindrical body wall 20, shown in vertical cross-section, comprises a plurality of wall segments 22. Although, as shown in FIGS. 1, 2 and 3, these segments are four in number, the invention also contemplates that the cylindrical section may have any number of segments, five or six, for example, subject to the conditions hereinafter set forth. The segments 22 are substantially symmetrical and are separated by longitudinal slots 28 which extend from the rear end of the cylindrical 20 body forward, over most of its entire length, terminating short of the forward most portion of the body. The purpose of the slots 28 is to provide weakened lines of separation of the body wall so that, under the influence of outwardly directed radial forces, the wall 20 will automatically split into the symmetrical segments 22. Further, the slots terminate at a forward point so that unweakened forward portion of the body 20 will offer greater resistance to fracture under radial stresses than the rearward body portions. In the examples shown, the slots 28 extend through the entire thickness of the body wall, although, as pointed out hereinafter, modifications of the depth of the cut are permissible. It should be further noted that the rear end of the body 20 is also notched or reduced slightly in diameter to receive a thin retaining ring 44 substantially flush with the exterior surface. The interior surface of the section 20 is provided with an annular recess 38 adapted to receive the enlarged annular base portion 36. The sabot projectile is thus conveniently assembled by placing a sub-caliber core within the body 14, attaching the body to the base 30 by flexing the segments 22 apart and bringing the base and body together until the enlarged base 36 aligns with the recess 38 and the elastic segments snap into place about the base portion 32, as shown in FIG. 2. The retaining ring 44 is applied to lock the aft ends of the segments into place to prevent separation during subsequent handling and loading of the projectile.

The nose section 24, as mentioned above, encloses the forward portion of the sub-caliber core 16 and it is preferable that the nose be tapered, similar to conventional projectiles, so that its exterior contours will assure compatibility with the loading and firing mechanisms of standard guns. The interior configuration of the nose section is not critical so long as it provides adequate room and protection for the forward portion of the sub-caliber core 16. In the embodiment of FIGS. 1-3, longitudinal grooves 46 are also symmetrically spaced around the base of the nose shield 24, preferably equal in number to the slots 28 in the body portion 20. The function of these grooves 46 is to assist in symmetrical separation and dispersal of the nose shield.

The projectile of this invention, and as described above, may be combined with a powder-containing cartridge 31, FIG. 2, of conventional type, or otherwise adapted for firing from a gun or rifle as desired. In the embodiments shown, the projectile is adapted for firing from a barrel having conventional helical rifling. However, other known means for achieving spin stabilization of the projectile in flight may be employed if desired.

The process of separation of the various sabot components after firing, demonstrating some of the objectives of the invention, generally proceeds according to the following sequence: At the instant of firing, the projectile 10 accelerates into the gun barrel, the slightly larger circular band 12 thus contacting the rifling in the barrel and effecting obturation as the projectile continues to move forward under the pressure of expanding gases. The ring 12, in addition to preventing by-pass of gases, turns with the rifling and thereby imparts spin to the sabot base and, hence, to the other sabot components. It may be noted that the spin moment is imparted to the subcaliber core because of the strong friction forces at the interface of the seat 34 and the core 16, generated by the great acceleration of the projectile. If desired, the resistance to slippage at the interface may be increased, and full spin assured, by providing a small sharp-edged groove or series of grooves in the base of the sub-caliber core. During initial acceleration, the softer metal of the sabot base will be swaged or pressed into such grooves, thus increasing transfer of torque between the base 10 and the core 16.

As the projectile accelerates through the length of the barrel, the spin imparted creates substantial centrifugal forces which tend to move the wall segments 22 radially with respect to the longitudinal axis of the projectile. These forces, however, are resisted by the surrounding walls of the gun barrel and thus substantial equilibrium is maintained while the projectile is within the barrel. Upon exit of the sabot body from the barrel, however, resistance to the centrifugal forces of rotation is suddenly diminished. As shown in FIG. 4, the rearward portions of wall segments 22 offer the least resistance and tend to move outward radially, exerting great tensile force on the thin restraining band 44. The band 44 ruptures and separation of the sabot body components is initiated by the outward flexing of the aft portions of the segments 22, while the forward ends are still restrained by the unslotted portion of the cylindrical body 20.

As the sabot base 10 continues to move forward and clears the muzzle exit, the high pressure gases within the barrel expand and are released to the atmosphere causing a strong stream of gas which is still accelerat-

ing. These accelerating gases actually overtake the projectile and impinge on the aft ends of the partially separated segments 22. This gas impingement augments the action of the centrifugal force already acting on the segments and assists in the further separation of the body components. It should be noted that this gas impingement has a forward component which may offset to some extent the aerodynamic drag forces already tending to slow the projectile. As a certain opening angle of the segments 22 is achieved, the combined forces cause fracture of the unslotted portion of the cylindrical sabot and the wall segments are discarded in a radial direction simultaneously with the fracturing of the body portion 20. The nose 24 is likewise fractured into substantially symmetrical segments defined by the grooves 46. These segments 48 are of low density and thus are decelerated very rapidly, presenting minimum danger to friendly troops. Although impingement of the muzzle gases significantly affects and improved the separation and dispersal of the body components of this projectile, due to the novel construction described, the sub-caliber core 16 itself is substantially protected from any adverse dispersing effect of the muzzle gases by the sabot base 10 which proceeds along the line of fire behind the core.

Following separation of the sabot body, aerodynamic drag forces rapidly decelerate the full caliber sabot base 10, which then falls far short of the target. The sub-caliber core 16, unrestrained and unhampered by the radial separation of other components, then proceeds along the line of fire to the target with minimum loss of velocity and minimum dispersion. It should be especially noted that separation of the core and base takes place without transfer of decelerating forces from the base to the core. FIG. 5 is a schematic representation showing the completely separated components, but it should be understood that the illustration, of necessity, does not show the parts in the actual spatial relationships that occur during the actual discarding process.

The separation of the sabot as described above normally occurs simultaneously upon leaving the gun barrel. It will be understood from the above description that the separation of the components under the influence of spin induced centrifugal force and the impingement of muzzle gases reduces to a minimum the velocity decay in the sub-caliber projectile due to transfer of decelerating and dispersing forces from the full-caliber components prior to complete separation of the latter from the sub-caliber core. In addition, the elimination of sliding surfaces between the core and other components holds friction forces, another major cause of velocity decay to a minimum and, further, the requirement for close machining tolerances is eliminated. Moreover, it will be seen that the method of separation provides minimum transverse effects on the sub-caliber core during separation and thus promotes improved hitting accuracy.

In another embodiment of the present invention illustrated in FIG. 6, the wall segments 52 of the sabot body 14 may have serrated interfaces 54 which interfit as shown, in lieu of the straight longitudinal slots 28. The generally longitudinally extending serrated interfaces permit separation of the wall segments in the manner previously described, but the serrations permit the transmission of shear forces between the segments and thus increase the structural rigidity of the cylindrical

body 20. This is a desirable advantage when the projectile may be subjected to substantial environmental shocks and loads, as in the case of automatic guns having extremely high rates of fire or guns having very high muzzle velocities. The serrated interfaces 54 also provide somewhat improved protection of the sub-caliber core 16 against other environmental conditions such as humidity, salt spray, dust, and the like.

FIGS. 7 and 8 illustrate a variety of modifications that can be made to the projectile of FIGS. 1-3, as may be desired according to convenience of manufacture, type of gun employed, the performance desired, or other requirements. It will be noted first that the sabot body 14 of FIGS. 7 and 8 is integrally formed, rather than comprising two separate sections as in the embodiment of FIG. 1. Further, it will be noted that the body 14 may be secured to the sabot base 10 by means of mating screw-threaded portions 66, 68 in the base and body respectively, rather than the retainer ring and assembly illustrated in FIGS. 1-3.

It will also be seen that rather than the full-depth longitudinal slots 28 or serrated interfaces 34, longitudinal cuts or grooves 64 of substantial depth may be made into the outer wall of the body 14 to form weakening lines which, upon rupture, divide the wall into substantially symmetrical segments 62, which otherwise are similar in function and operation to the segments 22. Preferably the grooves 64 are V-shaped and extend only partially into the wall of the sabot body, as shown more clearly in FIGS. 8 and 9. This partial grooving, in contrast to the full slotting shown in FIGS. 1 and 2, serves to increase the structural rigidity of the projectile. It further results in the additional advantage that the subcaliber projectile is completely enclosed, thus protecting it from certain adverse environmental conditions. The depth of the V-shaped groove may vary depending on the strength of the material used, so as to assure the breakage of the sabot wall along longitudinal lines in these areas under the influence of the specific centrifugal force that is applied to the projectile at the selected conditions of muzzle velocity and spin.

Further, it will be observed that the cuts or grooves 64 are formed so that the body wall is weakest, and therefore most susceptible to rupture, at the aft end and is strongest and least susceptible to rupture at the forwardmost end, so that separation under the centrifugal forces of spin will initiate at the rear of the body and progress forward toward the nose of the body 14. To insure initial rupture at the aft end, it may be desirable to vary the depth of the cut or groove 64, depending upon the strength characteristics of the particular material utilized, making the groove deeper at the aft end and progressively shallower toward the forward end.

As noted earlier, good projectile hitting accuracy of the projectile requires substantial co-axial alignment of the barrel axis, the sabot projectile axis, and the axis of the sub-caliber core. Apart from this condition, however, only a light press fit is desired between the sabot assembly and the sub-caliber core, and the machining tolerances between the sabot base and the contacting surfaces of the core are neither close nor critical.

A further modification illustrated in FIG. 8 is the provision of a small circular hole 70 through the bottom of the sabot base, providing communication between the rear face 30 of the sabot base and the base of the sub-caliber projectile 16. Such an opening is useful when it is desired to fire tracer projectiles. The opening pro-

vides access so that the burning propellant gases may ignite the tracer material at the rear of the sub-caliber projectile.

It may be further observed that the seat for the aft end of the sub-caliber core may be recessed into the sabot base 10 so long as care is taken to avoid significant frictional contact between the sides of such recess and the core. For example, in the embodiment shown in FIG. 8, the seat 72 is within an annular bore 74 provided in the forward portion of the sabot base 10. It is particularly important, however, that the bore 74 be of greater diameter than the base of the core 16, so that a loose fit is provided, and separation of the core and the base will not transmit deceleration forces to the core through sliding friction.

With any or all of the modifications described, the basic principle of sabot separation is maintained generally as described above. For example, in a projectile constructed as shown in FIGS. 7 and 8 separation initiates immediately upon exit of the sabot body 14 from the gun barrel. Separation of the body 14 begins at the aft end, in the vicinity of the threaded region, and progresses, as before, along the grooves 64 toward the nose. When the segments 62 have been partially opened by the centrifugal force of spin the aft ends of the segments are struck by the exhausting muzzle gas thus effecting complete separation and radial dispersion. Optimum dispersion is achieved when the segments, including the nose separate as symmetrically as possible, and therefore it is highly desirable that the projectile for a given application be designed to effectuate this objective.

It is, of course, possible to contemplate still further modifications and uses for the projectile herein disclosed. For example, rather than a solid sub-caliber core of high density, one may utilize the same discarding sabot principle in connection with other types of projectiles such as high explosives single flechette, multiple flechette, or the like.

Accordingly, in view of the wide applicability of the principles herein disclosed, I do not wish to be limited to the particular designs and embodiment herein disclosed. It therefore should be understood that other adaptations of my invention are intended to be comprehended within the meaning and range of the following claims.

What is claimed is:

1. A spin stabilized discarding sabot projectile adapted for firing from the muzzle of a gun comprising a sub-caliber core having a conical forward body portion and a generally cylindrical main body portion, a full-caliber sabot base having a forwardly extending member with a forwardly opening recess for receiving the core, a rotating band extending circumferentially around said base for imparting rotation to the projectile during traverse of a gun barrel, a sabot body covering the sub-caliber core, the sabot body having an internal recess for engaging the forwardly extending base member to mount the sabot body on the sabot base, said sabot body having a conical forward body portion, a plurality of grooves in said forward body portion, said sabot body having a rear body portion including a plurality of rear body segments threadedly secured to and extending rearwardly from the forward body portion in covering relationship to the core, said body segments being defined by slots extending longitudinally of the sabot body, a retaining ring for engaging the body seg-

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ments adjacent the base for securing the body segments in fixed relation to each other, and for cooperating with the rear body portion to secure the core in axial alignment with said projectile, said retaining ring for fracturing on the application of centrifugal force to the projectile and for releasing the body segments of the sabot body to separate radially from the core initially at the rear portion of the sabot body and to further separate from the core progressively toward the forward body portion so that the rearwardly separated body segments are exposed to the force of propelling gases issuing

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from a gun barrel which gases impinge upon the body segments to discard the sabot body from the sub-caliber core, and so that the sabot base is exposed to aerodynamic drag forces for removal from the core.

2. The projectile defined in claim 1 in which the base and the body segments are recessed to receive the securing ring.

3. The projectile according to claim 1 in which the longitudinally extending slots comprise serrated interfaces between the body segments.

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