Feb. 23, 1954

P. F. DARBY ET AL

2,669,930

SABOT PROJECTILE

Filed Jan. 5, 1946

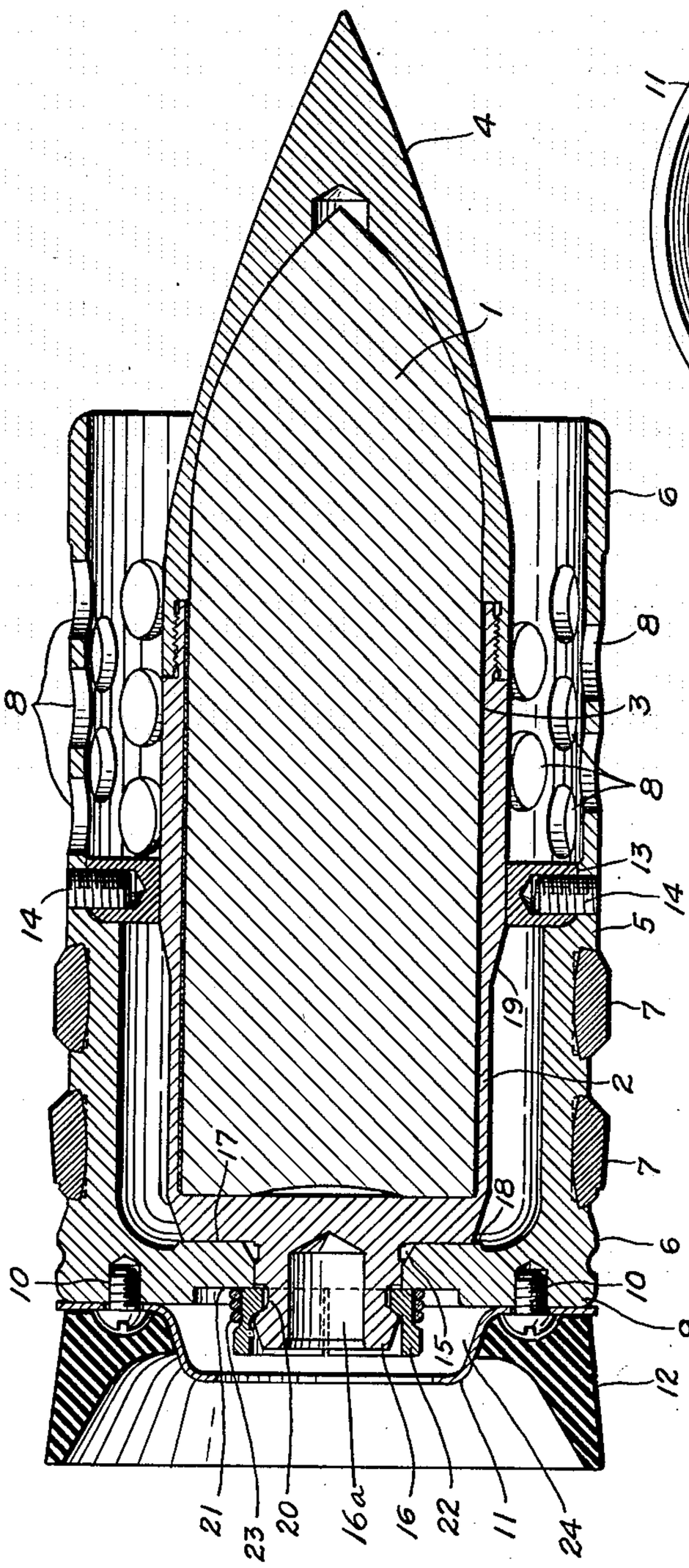

Fig. 1

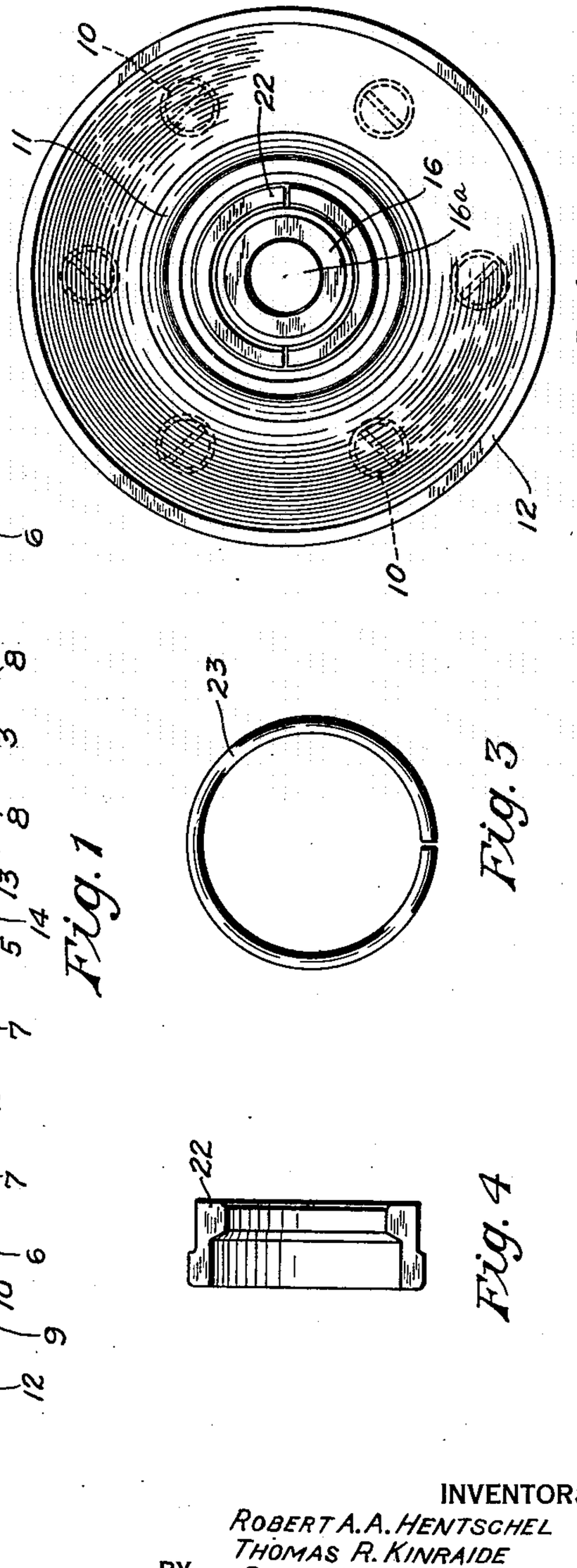

Fig. 2

Fig. 3

Fig. 4

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Patented Feb. 23, 1954

2,669,930

UNITED STATES PATENT OFFICE

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SABOT PROJECTILE

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Application January 5, 1946, Serial No. 639,174

4 Claims. (Cl. 102—93)

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This invention relates to an improvement in projectiles and more particularly to high velocity projectiles adapted for the penetration of armored structures.

Since the earliest use of iron clad naval craft and particularly since the more recent introduction of armored military land vehicles whose weight and gun carrying capacity are limited by demands for maneuverability, there has been a constant struggle for superiority between the makers of armor plate and the makers of armor piercing ammunition. Each improvement in the ballistic strength of the armor plate or increase in the thickness of armor carried has brought about an increase in effectiveness of the ammunition expected to be used against such plate. Likewise, each improvement in the effectiveness of the projectile has usually been countered by a succeeding improvement in the armor plate.

This invention follows the present trend of the cycle and its primary objects are to effect a major improvement in the penetrative effectiveness of armor piercing ammunition and to, at the same time, effect a great improvement in the accuracy with which such fire may be delivered.

It is a further object to produce an effective subcaliber projectile which may be utilized without damage to the gun or parts thereof such as the muzzle brake.

An additional object is to furnish a projectile which may be economically and conveniently manufactured and assembled with a minimum of machine work necessary on difficultly machineable components.

The invention contemplates accomplishing these objects by the use of a subcaliber projectile including a very hard and high density core, of substantially less than bore diameter, assembled in combination with a sabot of substantially bore diameter, the combination having materially less weight than the standard full caliber round. The sabot performs the functions of sealing the bore of the arm, imparting rotation to the subcaliber projectile, and guiding the same during its travel in the bore of the arm. During the combustion of the propellent charge, the sabot projectile receives from the charge substantially the same amount of energy as would normally be imparted to a standard full caliber round of approximately twice as great weight. As a result of this light weight, the velocity is much higher than that of a standard round, although little or no greater chamber pressure has been required.

Upon emergence of the sabot subcaliber projectile combination from the barrel of the gun, separation takes place and the subcaliber projectile which offers relatively small area to air resistance and is designed for high ballistic efficiency continues on its flight alone. The subcaliber projectile, in proportion to its physical dimensions, is very heavy and the major part of the kinetic energy imparted to the assembly is effective in maintaining the velocity thereof. By reason of its small physical dimensions, its retardation is comparatively low and its remaining velocity on impact is materially greater than that of standard rounds. The sabot having a conformation unsuited for exterior ballistic efficiency decelerates and falls to the ground.

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It is appreciated that this same general approach to the problem has been previously tried but the projectiles of the prior art suffered greatly from the lack of accuracy. Their design limitations were also such that they were apt to break up or become disassembled as they passed through the bore or else they would fail to separate at all. The problem may be better appreciated if it is realized that the sabot is given a strong impetus forward on the initiation of combustion in the propellent charge, and that as the rifling bands of the sabot seat firmly in the rifling, the sabot itself is rather violently decelerated and the subcaliber projectile tends to continue without the sabot. As soon as the pressure has built up sufficiently to overcome the resistance of the rifling, the sabot is again violently accelerated and, if there has been any separation, overtakes the subcaliber projectile with a severe impact apt to shatter the base of the sabot. The difficulty of preventing smash-ups in the bore without impeding the instant separation of the parts on emergence therefrom has been a serious one.

Another serious problem has arisen in connection with previous projectiles of this general type in that the sabot was apt to develop and transmit to the subcaliber projectile yawing tendencies too great to be cancelled out by the gyratory action of the spinning core. Akin to this defect has been one which may arise outside the bore when the sabot may yaw at the instant of separation and divert the axis of the spinning subcaliber projectile. Any such yawing force applied to the subcaliber projectile results in the development of gyratory precession and seriously disturbs the true flight of the projectile. As will appear more fully hereafter, this invention presents a practical solution to both of the problems mentioned.

The exact nature of the invention as well as other objects and advantages thereof will be readily apparent from consideration of the drawing, in which:

Fig. 1 is a longitudinal cross-section taken on the axis of a preferred form of the invention.

Fig. 2 is a rear end elevation of the projectile shown in Fig. 1.

Fig. 3 is an elevational view of one of the retaining springs.

Fig. 4 is a side elevation of one of the retaining shoes.

Referring to the drawing by characters of reference, it may be seen that the invention comprises two major units, of which the first to be described is the subcaliber projectile. The principal part of this subcaliber projectile is an extremely hard and high density penetrating core 1. A preferred material for this core is tungsten carbide, which may be sintered in the well-known manner with cobalt or some other suitable metal. Suitable proportions are from 87% to 90% tungsten carbide and 10% to 13% cobalt. It will, of course, be realized that the principles of this invention are equally applicable to other choices of material for the penetrating core.

The difficulty of machining the materials suitable for use as penetrating cores is well known and for mass production it has been a practical necessity that the contours of the core be kept to the simplest form consistent with accomplishing their intended purpose. Tungsten carbide is normally molded into bars from powder form, machined to size, and sintered, after which further machining operations can only be carried out by the expensive process of grinding with diamond wheels. In order to permit the utilization of simple shapes and to allow the other requirements to be met without requiring grinding of the heat treated core to extremely precise radial dimensions there has been provided an enclosing sheath 2 of steel or other suitable, easily machineable material which engages the core and provides for its secure attachment to and ready release from the sabot to be later described in detail.

The sheath has an internal diameter slightly larger than may be expected of the largest unground core which will come within specification tolerances in regard to diameter, eccentricity, and the like. A suitable method of insuring that the core is adequately and concentrically joined to the sheath is to insert the core into the sheath and space it in centered relation thereto by the insertion at 120° intervals of three identical wires of the largest diameter that may be forced into the annular gap. This assembly is then preheated and there is cast into the gap a matrix of fusible alloy 3 such as typemetal or other high lead-bismuth content alloy having the characteristic of expansion on cooling. It is desirable to select the heaviest available matrix material in order to match as closely as possible the density of the core and thus minimize weight variations in the complete assembly. Upon cooling, the matrix material will expand and tenaciously grip the rough surface of the unground core.

Secured to the front end of the sheath 2 by a threaded or other suitable connection is a nose cap 4 of Duralumin or other light metal enclosing the nose of the core 1. This nose cap has the usual functions of improving ballistic efficiency by its streamlining effect and on impact aids penetration by furnishing lateral support and lubrication to the point of the core.

The second major unit, or the sabot, is built up from the cup-like body 5 which is provided on its front and rear outer cylindrical surfaces with carefully machined bearing areas 6. These bearing areas are adapted to ride on the surface of

the lands of the rifling without being engraved as the projectile passes through the barrel. The function of imparting rotation to the subcaliber projectile by engagement with the rifling is performed by the rotating bands 7 which are seated in suitable grooves in the sabot body preferably somewhat to the rear of the center of gravity of the assembled sabot-subcaliber combination.

At least one of the rotating bands is formed with a portion of diameter great enough to engage the wall of the chamber in the rear of the forcing cone and insure that the sabot will be centered in the bore in spite of possible irregularities in the thickness or alignment of a cartridge case in the chamber. This feature requires that the band be capable of withstanding an augmented radial compression without damage to the rifling. It has been found that a porous sintered iron rotating band is admirably suited to this purpose since it compresses radially without any tendency to flow back and simply becomes more dense in the region immediately in contact with the rifling. Although the shear strength per unit area of sintered iron is not as great as that of some previously used materials, its ready compressibility enables large areas to be used without overloading the rifling. The melting point of the sintered iron band is higher and its coefficient of friction under working conditions appears to be less than that of the other conventional materials. Such bands do not, therefore, wear off or become subject to local fusion where they contact the rifling. The action of this material is also more uniform and less subject to uneven deformation than that of some solid materials. Preferably such bands are impregnated with paraffin or other suitable lubricant which has the dual function of rustproofing the band and lubricating the bore. The effectiveness of such bands is evident from an inspection of sabots fired for recovery. The engraving of the bands is clean cut and uniform, whereas when the bands are of other materials the bands themselves show wide, ragged grooves of much greater extent than required for the passage of the lands of the rifling.

To decrease the weight of the sabot, approximately its front half may be perforated with holes such as those shown at 8.

The basal portion 9 of the cup-shaped sabot provides a rearwardly and inwardly extending flange whose function will be more fully discussed hereinafter. The retaining flange may be integral with the sabot or may comprise a retaining washer 11 secured thereto as by screws 10.

Cemented to the rear face of the retaining washer is an obturator cup or gas check 12 which may be formed of rubber, neoprene, or other plastic rubberlike material. The flared skirt of such an obturator receives the pressure of the propellent gases and functions as an effective seal to prevent the possibility of non-uniform application of gas pressure in the annular space in the rear of the rotating bands. The effectiveness of this obturator may also be determined by the inspection of the bodies of sabots fired for recovery. Unless such an obturator is used, the sabot body will be deeply scored or engraved, showing that there has been a non-uniform pressure application tending to cant the assembly in the barrel.

A bearing band 13 may be formed integrally with the sabot body, or for lightness in weight and convenience in machining, may be of Duralumin or other suitable light metal received in the cup-like sabot body and secured thereto with

the inner face of the bearing band concentrically disposed with relation to the axis of the cup. To insure absolute accuracy, if the bearing band is a separate element, it is preferable that the bearing band 13 be shrunk into its seat and ground to a perfect fit with the sheath. It may be further retained by the use of set screws such as those shown at 14. The base 9 of the cup 5 is centrally apertured at 15 to receive with a very accurate fit the rearward extension 16 formed on the base of the core sheath 2, and carefully machined mating flat surfaces are provided on the rear face 17 of the sheath and on the forwardly facing inner surface 18 of the base of the body. The extension may conveniently be formed to include a tracer cavity 16*a*. The outer surfaces of the sheath and nose cap are spaced a considerable distance radially inward from the inner surface of the front portion of the body, and the sheath is diametrically reduced at 19 in the region to the rear of the bearing band. This clearance has an important bearing on the accuracy, with which the subcaliber projectile separates from the sabot and will be discussed in more detail hereafter.

The rearward extension on the sheath is provided with a circumferential groove 20 in the region immediately behind the rearward face 21 of the base of the sabot body. Half-circular retaining shoes 22 (see Fig. 4) are adapted to encircle the rearward extension and are provided with inner surfaces adapted to be engaged in the groove in the rearward extension in such fashion as to provide a wedge-like action between the forwardly facing rear wall of the groove and the rearwardly facing base of the body. These segments or retaining shoes are secured in the groove by having retaining springs 23 engaged about their outer circumference. Each of the springs (see Fig. 3) is preferably in the form of a substantially complete circle and the springs are adapted under the action of centrifugal force to expand to a degree sufficient to permit the retaining shoes to disengage themselves from the groove.

To insure that the springs and retaining shoes do not fly promiscuously about in the bore of the gun and in particular to avoid damage by these parts to the surface of the bore and to the muzzle brake, the retaining flange or washer 11 is provided on the rear face of the sabot body. It will be noted that the retaining flange provides an annular recess 24 of ample dimensions to receive the expanded spring rings and the retaining shoes within which they will be retained by centrifugal force until after the sabot has cleared the muzzle brake.

In use, this projectile may be loaded into a gun and fired in the usual manner, either as an element of fixed or separate loading ammunition. Upon firing of the propellent charge, the sabot receives a forward impetus of considerable magnitude, and by reason of the inter-engagement between the sheath and the sabot body, this forward impetus is communicated to the subcaliber projectile assembly. The retaining shoes 22 and springs 23 adequately resist the tendency (heretofore noted) of the projectile to separate from the sabot when the latter is retarded by its initial engagement with the rifling. During the period in which this tendency toward separation is likely to be active, the combined projectile assembly will not have acquired a significant rotational velocity. Thus, the full shearing area of the retaining shoe ribs is available to resist such separation during the period when

it is needed the most. As the projectile assembly moves through the gun barrel, there will be sufficient acceleration of the assembly to insure that the forces of inertia maintain high pressures at the contacting face between the subcaliber sheath and the base of the sabot. This engagement functions in the manner of a friction clutch to transmit to the sheath and therefore to the core of the subcaliber projectile the rotating force applied to the sabot by the inter-engagement of the bands and the rifling. The centrifugal force generated by rotation as the projectile moves through the bore overcomes the resistance of the spring rings and allows the segments of the retaining shoes to become disengaged from the extension on the rear of the sheath. The retaining flange provides a compartment in which the springs and retaining shoes are received and held by the continued action of centrifugal force. It is of considerable importance that the retaining flange function in this manner for otherwise retaining shoes and springs would be at liberty to contact the walls of the bore with possible injury to them and would almost certainly do severe damage to the muzzle brake.

During the passage of the projectile assembly through the bore, the gas check functions in a manner similar to that of the well-known cup pump leather and completely seals the bore against any penetration of gas through the annular space surrounding the sabot body. This has the effect of protecting both the bore and the rifling bands from the effects of gas erosion, which are severe when any leakage is permitted, as well as insuring the uniformity of pressure application previously mentioned. While it may seem that there would be a tendency for gas pressure to force the subcaliber projectile forwardly from its seat in the sabot, it should be borne in mind that the subcaliber projectile is largely composed of very high density material. Since the whole assembly is accelerating at a very high rate as it passes through the bore, the normal forces of inertia will hold the subcaliber projectile on its ground seat with sufficient bearing pressure to overcome the possibility of any leakage or slippage due to rotary acceleration.

When the projectile assembly leaves the muzzle of the gun, air resistance acting on the sabot will cause it to decelerate rapidly. The subcaliber projectile presents a much smaller body and one which is properly shaped for minimum air resistance. It will be seen, therefore, that the subcaliber projectile will separate at once from the sabot. It was previously pointed out that there is a considerable clearance between the forward portion of the sabot and the projectile sheath and that the rearward portion of the sheath was reduced in diameter immediately behind the bearing ring. Thus, as soon as there has been any appreciable relative axial movement between the sabot and the subcaliber projectile, the projectile will be substantially free from any forces that might be exerted by the sabot. If, for example, the sabot tended to yaw in the process of separation, it would be impossible for this force to be transmitted to the subcaliber projectile in such manner as to disturb its true flight. The fact that the sabot is provided with widely spaced bearing areas at its end portions, that it is thoroughly obturated and that the rifling bands are true and of ample strength insures that the sabot and subcaliber assembly will have been delivered from the muzzle of the gun without initial yaw. The axial separation necessary to

free the subcaliber projectile takes place in the first few feet of free flight and during this short interval the sabot will not have an opportunity to develop or to transmit to the subcaliber projectile yawing tendencies having an adverse effect on accuracy.

After separation of the subcaliber projectile from the sabot, the latter which presents a very poor ballistic contour, will rapidly decelerate and fall to the ground. The subcaliber projectile will continue by itself at an extremely high velocity and on impact with the target the nose cap will perform the usual function of lubricating and supporting the point of the penetrating core. The penetrating core is, as has been previously noted, of very high density, and being composed largely of one of the hardest known materials is well adapted for the penetration of armor. As the core penetrates, the sheath will probably be stripped off, but since its mass is insignificant in comparison with that of the core itself, the loss of the momentum of the sheath will not exert an appreciable effect upon the penetrative effectiveness of the core.

We claim:

1. In a sabot projectile for rifled guns comprising an assembly of a sabot with a subcaliber projectile; the combination including a sabot having an axially apertured base, flanged means on the sabot provided with a central opening and defining an annular recess surrounding and extending rearwardly from the rear opening of the apertured base, a subcaliber projectile engaging the sabot and having an axial rearward extension provided with a tracer cavity reaching through the aperture in the sabot base, an annular groove in the extension; and centrifugally releasable retaining means comprising segmental retaining shoes engaged between the annular groove and the sabot base, and a plurality of spring rings embracing the shoes, the said recess providing an annular compartment for the reception and carrying of the releasable means when their release has been effected by rotation of the assembly, while allowing said tracer cavity to be rearwardly exposed through said central opening.

2. In a sabot projectile for rifled guns comprising an assembly of a sabot with a subcaliber projectile; the combination including a sabot comprising a generally cylindrical deep cup-shaped member having an open forward end and a centrally disposed aperture in the base thereof, spaced bearing surfaces on the exterior of the sabot adapted to slide on the surface of the lands of a rifled gun, rotating band means located between the spaced bearing surfaces, a rearwardly and inwardly extending flange on the base of the sabot provided with a substantially axially disposed opening and defining an annular recess surrounding and extending rearwardly from the rear opening of the aperture in the base, a supporting band within the sabot spaced rearwardly from the open end thereof by not substantially less than one-half the depth thereof and having therein an opening coaxial with the exterior bearing surfaces and with the aperture in the base; a subcaliber projectile of substantially less maximum diameter than the inside diameter of the sabot forward of said supporting band comprising a generally cylindrical portion received within the supporting band, a base in engagement with the base of the sabot, an extension on the base of the subcaliber projectile reaching through the aperture in the base of the sabot and provided with a tracer cavity exposed to said axially disposed opening, an annular groove in the extension; and centrifugally releasable retaining means within said annular recess comprising retaining shoes engaged between the annular groove and the base of the sabot, and spring means releasably encircling the retaining shoes.

3. In a sabot projectile for rifled guns comprising an assembly of a sabot with a subcaliber projectile; the combination including a sabot comprising a generally cylindrical deep cup-shaped member having an open forward end and a centrally disposed aperture in the base thereof, longitudinally spaced bearing surfaces on the exterior of the sabot adapted to slide on the surface of the lands of a rifled gun, rotating band means located on the exterior of the sabot between the bearing surfaces, a foremost internal supporting band within the sabot spaced rearwardly from the open end thereof by not substantially less than one-half the depth thereof, said supporting band having therein an opening coaxial with the exterior bearing surface and with the aperture in the base; a subcaliber projectile of substantially less maximum diameter than the inside diameter of said sabot forward of said supporting band comprising a generally cylindrical portion received within the supporting band, a base in engagement with the base of the sabot, an extension on the base of the subcaliber projectile reaching through the aperture in the base of the sabot, the diameter of the body of the subcaliber projectile in the rear of the supporting band being so reduced that after slight axial separation there is freedom for relative inclination between the axis of the subcaliber projectile and the axis of the sabot; and centrifugally releasable means for securing the subcaliber projectile in the sabot until the assembly has attained a predetermined rotational velocity, said releasable means comprising separable shoes inter-engaged between the rearmost face of the base of said sabot and the portion of said extension reaching entirely through said aperture in the base of the sabot.

4. In a sabot projectile for rifled guns comprising an assembly of a sabot with a subcaliber projectile; the combination including a sabot comprising a generally cylindrical deep cup-shaped member having an open forward end and a centrally disposed aperture in the base thereof, longitudinally spaced bearing surfaces on the exterior of the sabot adapted to slide on the surface of the lands of a rifled gun, rotating band means located on the exterior of the sabot between the bearing surfaces, a foremost internal supporting band within the sabot spaced rearwardly from the open end thereof by not substantially less than one-half the depth thereof, said band having therein an opening of greater diameter than the aperture in the base coaxial with the exterior bearing surfaces and with said aperture; a subcaliber projectile of substantially less maximum diameter than the inside diameter of the sabot forward of said supporting band comprising a generally cylindrical portion received within the supporting band, the subcaliber projectile being reduced in diameter behind the supporting band, a flat base in engagement with the base of the sabot, an extension on the subcaliber projectile engaged with the aperture in the base of the sabot and extending therethrough; and centrifugally releasable means for securing the subcaliber projectile in the sabot until the assembly has attained a predetermined rotational velocity, said releasable means comprising separable shoes inter-engaged between the rearmost

face of the base of said sabot and the portion of said extension extending entirely through said aperture, and spring means releasably encircling said shoes.

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