The present invention relates to the use of plastics for rotating bands on projectiles fired from rifled gun barrels. The plastic band is injection molded into a circumferential channel provided in the projectile body. The cross section of the circumferential channel is designed such as to provide a tight gas seal between the plastic rotating band and the projectile body, to assure transfer of spin introduced by the rifling in the gun barrel and to secure the rotating band to the projectile after exit from the muzzle of the gun. The portion of the plastic rotating band protruding beyond the projectile body engraves and is compressed into the rifling groove of the gun barrel, thus obturating the propellant gases and transmitting the spinning motion to the projectile. The plastic rotating band is lighter and costs less than conventional metallic rotating bands and is, in addition, a noncritical war material. Furthermore, its use yields better obturation and reduced barrel wear than is obtained with conventional rotating bands.

7 Claims, 6 Drawing Figures
ROTATING BAND FOR PROJECTILE

BACKGROUND OF THE INVENTION

A spin stabilized projectile develops a spin or rotational motion about its longitudinal axis as the projectile moves through a gun barrel. The projectile carries a rotating band which is a ring-like member encircling the aft end of the boullelet section of the projectile. The band protrudes circumferentially from the projectile body so as to engage the rifling grooves of the gun barrel. During firing of the projectile, the rotating band engages into the rifling grooves and imparts spin to the projectile according to the rifflng twist as the projectile advances through the gun barrel. In order for the projectile to develop the desired spin, the rotating band must not slip in the rifflng grooves as through inadequate engraving and additionally the band must not slip with respect to the projectile body. Either condition will result in failure of the projectile to develop full spin. The action of the gas pressure during launch, inertial forces and frictional forces along the barrel wall will result in shear forces between the rotating band and the projectile body. The strength of the rotating band and of its attachment to the projectile body must be adequate to withstand the shear forces and to avoid unwanted slippage.

The rotating band must also perform as an obturator and prevent leakage of the powder gases between projectile body and barrel. Insufficient obturation will result in decreased muzzle velocity. Small leakages can lead to very high velocities of the escaping hot powder gases causing erosion of the barrel walls which is a major factor in reducing barrel life. Thus, the engraving of the rotating band with the rifflng grooves of the barrel has to be complete for satisfactory obturation and remain that way during the entire travel of the projectile in the gun barrel.

Upon exit of the projectile from the muzzle, the rotating band must remain on the projectile. Disintegrating rotating bands represent a hazard to friendly troops and in the case of aircraft mounted guns may cause damage to aircraft components as through ingestion into the powerplant for instance. Unsymmetric deformation of the rotating band subsequent to muzzle exit will contribute to projectile dispersion and trajectory deviations.

The rotating band must perform the functions described above over the entire range of environmental military conditions, i.e., −65°F to 135°F. The use of a noncritical war material for rotating bands is desirable.

Copper alloys and sintered iron are the conventional materials used for the manufacture of rotating bands. For some time the application of plastics as a rotating band material has been investigated, the primary advantages of plastics being light weight, low cost, and low barrel wear. So far the design and employment of plastic rotating bands has not been fully successful for a variety of reasons.

One approach has been to secure a plastic rotating band to a metal projectile body by means of a bonding material such as an epoxy. There are numerous disadvantages in bonding for this particular application. The shear strength of a well-applied bond between a plastic and a metal surface is on the order of 1,500 psi, depending on the specific adhesive and the materials to be bonded. This limited shear strength either requires a wide rotating band configuration or the use of multiple bands in order to transmit the shear forces acting between the rotating band and the projectile body. The use of wide or multiple rotating bands is undesirable since they induce an increase in aerodynamic drag of the projectile during flight.

A further disadvantage of bonding agents is their diminishing shear strength with time (aging resistance). In addition, experience indicates that bonds gradually weaken with age in atmospheres of high humidity. These characteristics limit the shelf life of the ammunition and adversely affect its immunity to adverse environmental conditions. These disadvantages are unacceptable for military applications.

Last, there are no valid inspection and quality control methods to assure the quality of a bond other than by destructive testing. This constitutes a severe handicap, particularly considering the high production rates in the manufacture of ammunition and the high reliability requirements for ammunition fired from automatic weapons.

SUMMARY OF THE INVENTION

According to the present invention, a plastic rotating band is applied preferably by injection molding to a circumferential groove on the main projectile body. The width of the plastic band is approximately 50 percent larger than that of conventional metal bands. The present invention provides a configuration for the circumferential groove in the projectile body. The circumferential groove for the plastic band contains a smooth cylindrical section at its rear portion. This section acts as the gas seal and prevents access of the high pressure propellant gases to the interface of the rotating band and the projectile body. Ahead of the gas seal the circumferential groove contains a knurled section which is required to transmit the rotational motion induced by the rifling grooves of the gun barrel to the projectile body without slippage. Access of high temperature and high pressure propellant gases to the knurled section such as would occur in the absence of the gas seal will result in an excessive deformation of the rotating band subsequent to emergence from the gun barrel, thus causing aerodynamic asymmetries and/or loss of the rotating band. The shoulders of the circumferential groove in the projectile body are dovetailed to strengthen the seat of the rotating band, thus preventing its disengagement upon exit from the gun barrel.

A ductile plastic such as a polycarbonate resin or a plastic of similar strength properties is used as band material. The physical properties required are such as to permit adequate engraving of the rotating band with the rifling grooves of the barrel without fracturing the band, and also to provide sufficient tensile strength to withstand the centrifugal loads imposed on the band by the high spin rate of the projectile.

The present invention can be applied to any spin stabilized projectile. The dimensions and detailed design depends on the particular projectile—gun configuration and the specific plastic material selection.

The plastic rotating band can be applied to projectiles manufactured of different metals, plastics, etc.

OBJECTS OF THE INVENTION

It is an object of the present invention to provide a plastic rotating band which can be applied to any spin
stabilized projectile fired from a rifle gun barrel. Another object is to provide for a plastic rotating band which can be fabricated from low cost, non-war critical materials, using efficient production methods. A further object of the present invention is to provide a low weight rotating band permitting an increase in payload or an increase in muzzle velocity of the projectile. A further object is to provide a rotating band having improved ductility and elasticity to yield superior propellant gas obturations to those obtainable with conventional metal rotating bands resulting in higher muzzle velocities for equal weight projectiles, propellant charges and maximum chamber pressures. A further object is the reduction of barrel wear through the use of plastic and thus the extension of the useful life of gun barrels.

DESCRIPTION OF THE DRAWING

A preferred embodiment of the invention has been chosen for purposes of illustration and description, and is shown in the accompanying drawing, forming a part of the specification, wherein:

FIG. 1 is a side elevation view partially in section of a projectile having a rotating band according to the present invention;

FIG. 2 is an enlarged view of the sectioned portion of FIG. 1;

FIG. 3 is a fragmentary plan view of a projectile showing the circumferential groove with the rotating band removed;

FIG. 4 is a section view taken along line 4—4 of FIG. 2;

FIG. 5 is a section view showing a projectile within a gun barrel; and

FIG. 6 is a section view taken along line 6—6 of FIG. 5 showing the rotating band of the projectile engraved into the gun barrel rifling.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawing, a projectile 10 according to the present invention includes a projectile nose or ogive section 12 and a breech section 14. A recessed groove 16 may be provided on the breech section for crimping of the cartridge case (not shown) to the projectile for final assembly. The breech section has a recessed, circumferentially extending groove 18 for receiving a rotating band 20. During launch, the rotating band serves as a gas seal to prevent escape of propelling gases past the projectile in the gun barrel 22 (FIG. 5) so that maximum propelling energy is delivered to the projectile. In addition, the rotating band engages into the rifling grooves 24 of the gun barrel to impart spin to the projectile.

According to the present invention, the circumferential groove 18 in the projectile cooperates with the rotating band to provide a gas seal at the interface between the rotating band and the surface of the projectile at the base 26 of the groove so to prevent the escape of propelling gases past the interface. In addition the circumferential groove 18 cooperates with the rotating band 20 to transmit spin without slippage to the projectile as the projectile moves and spins along the axis of the gun barrel.

As shown in the drawing, the groove 18 includes a generally channel form cross section extending circumferentially of the projectile and defining a generally cylindrical base 26 and upstanding shoulders 28, 30. Each shoulder inclines approximately 30° measured from the vertical to define confronting dovetail shoulders for retaining the rotating band. The cylindrical base 26 of the groove is smooth over its aft portion 26a. Preferably the smooth section 26a covers approximately one half the surface of the base 26. The provision of the smooth section 26a is essential in the use of plastic as rotating band material in order to form the gas seal at the interface between the rotating band and the projectile body.

For projectiles having calibers from 20 to 30 millimeters, the width of the smooth cylindrical section 26a should be no less than 0.2 calibers. Ahead of the smooth portion is a knurled section 26b followed again by a shorter smooth portion 26c. Radii 32, 34 define the junctures of the cylindrical base portions 26a and 26c with the dovetailed shoulders 30 and 28 respectively. The width of the knurled section 26b is dimensioned such to assure the transmission of spin induced on the rifling to the projectile without slippage. Among other factors, this is a function of the rifling twist of the weapon and the axial moment of inertia of the projectile. The dovetailed shoulders 28 and 30 of the circumferential groove serve to contain the rotating band 20 after assembly and also during the flight of the projectile subsequent to emergence from the barrel.

The cylindrical section 20a of the exterior of the rotating band which protrudes beyond the diameter of the projectile body engages the rifling grooves 24a of the gun barrel 22 (FIGS. 5 and 6). The outside diameter of the cylindrical section of the rotating band is dimensioned such as to completely fill the rifling grooves upon emerging in the barrel, causing a compression of the band exceeding the compressive yield strength of the plastic as shown in FIGS. 5 and 6. The configuration of the rotating band protruding beyond the cylindrical main projectile body has a ramp 20b at its forward end with a ramp angle of approximately 20°. This ramp assures a gradual initiation of engraving and is furthermore desirable for aerodynamic reasons during the flight of the projectile.

The rear end 20c of the band has a shoulder angle equal to the dovetail, i.e., approximately 30°. The width of the cylindrical section of the rotating band is approximately 1.5 times the width of an equivalent metal rotating band for the same projectile.

The compression of the rotating band is necessary to to satisfactorily obstruct the high pressure powder gases. The engraving of the band takes place automatically upon firing and initial motion of the projectile into the rifled gun barrel. To accomplish the substantial deformation of the band during engraving without breakage, a ductile and plastic material such as a polycarbonate resin, nylon 12 or high density polyethylene, or equivalent is required. The physical properties of some applicable plastics are listed below:

<table>
<thead>
<tr>
<th>Plastic</th>
<th>Tensile Strength</th>
<th>Elastic Modulus</th>
<th>Impact Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poly-carbonate</td>
<td>9,500 psi</td>
<td>3.4x10^6 psi</td>
<td>16 fl. lb./in.</td>
</tr>
<tr>
<td>Merlon</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Lexan</td>
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<td></td>
<td></td>
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<tr>
<td>Zelux</td>
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<td></td>
</tr>
<tr>
<td>Etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nylon 12</td>
<td>8,000 psi</td>
<td>2x10^6 psi</td>
<td>4.2 fl. lb./in.</td>
</tr>
<tr>
<td>High Density</td>
<td>5,400 psi</td>
<td>1x10^6 psi</td>
<td>20 fl. lb./in.</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>(high density,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>high molecular</td>
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<td></td>
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</table>
The physical properties of these plastics are such that they can be employed successfully over a temperature range from -65°F to 135°F.

Plastics are subject to shrinkage subsequent to injection molding. The combination of post-molding shrinkage and surface tension causes a withdrawal of the plastic from the sharp concave corners 26c of the knurled section, thus leaving open channels through which high pressure gases could escape. Hence, the knurled section 26b does not in itself form an adequate gas seal. This phenomena is unique for plastics due to their inherent molding shrinkage and does not apply to conventional metal rotating band materials. Therefore in using plastic as a rotating band material the knurled section has to be backed up by a gas seal 26a. Over the smooth cylindrical section 26a, the post-molding shrinkage of the plastic causes a tightening of the plastic around the metal thus forming a very effective gas seal at the interface of rotating band and projectile. In order to prevent the withdrawal of the plastic from the intersection formed by the cylindrical sections and the dovetailed shoulders, the corners are suitably radiused at 32 and 34.

During flight the projectile is spinning at a rate determined by the rifling twist of the barrel and the muzzle velocity. For a 20 millimeter gun having a rifling twist of 7° and a projectile fired at a muzzle velocity of 4,000 feet per second, for instance, the rate of spin is 2,375 revolutions per second. The resultant centrifugal forces acting on the plastic band induce a hoop stress with the tendency to expand the rotating band. The dovetailed shoulders of the circumferential groove prevent the expansion of the band and contain it in its original position.

What is claimed is:

1. A projectile, a groove extending circumferentially of the exterior of the projectile, said groove being recessed below the surface of said projectile and having a generally cylindrical section extending circumferentially of projectile together with generally dovetailed fore and aft shoulder portions defining the sides of said groove, a plastic rotating band located in said groove and extending above the groove surface beyond the diameter of said projectile to engage gun rifling to obturate the propellant gases and impart spin to the projectile during launch, said cylindrical section having a smooth aft surface covering approximately one half of said cylindrical section, a knurled portion located forwardly of said aft surface, and a shorter smooth surface located forwardly of the knurled surface.

2. A projectile according to claim 1 in which said rotating band comprises an injection molded plastic.

3. A projectile according to claim 1 in which said rotating band comprises injection molded nylon 12.

4. A projectile according to claim 1 in which said rotating band comprises an injection molded high density polyethylene.

5. A projectile according to claim 1 in which said rotating band comprises an injection molded polycarbonate.

6. A projectile according to claim 1 in which said rotating band comprises an injection moldable plastic having an elastic modulus of not less than $1 \times 10^9$ psi, a tensile strength of not less than 5,400 psi and an IZOD impact strength (notched) of not less than 4 pounds per inch.

7. A projectile according to claim 1 in which said rotating band comprises a ductile, elastic plastic having a density of 0.043 pounds per cubic inch, a modulus of elasticity of $34 \times 10^9$ psi, and tensile strength of 8,500 psi.