March 15, 1960 W. A. ZISMAN ET AL 2,928,348

PROJECTILE ROTATING BAND

Filed Jan. 7, 1955

FIG. 1

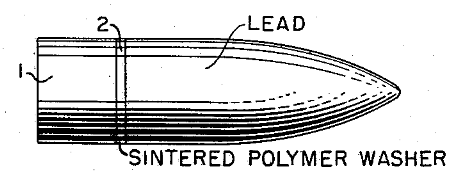


FIG. 2

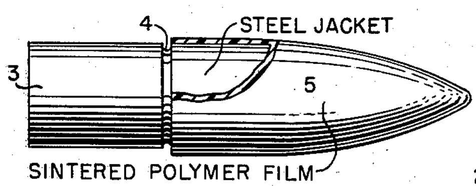


FIG. 7

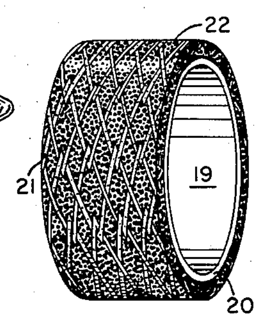


FIG. 3

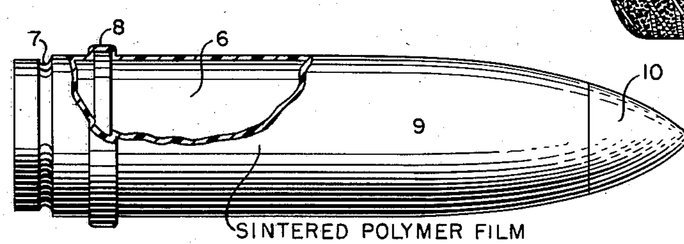


FIG. 4

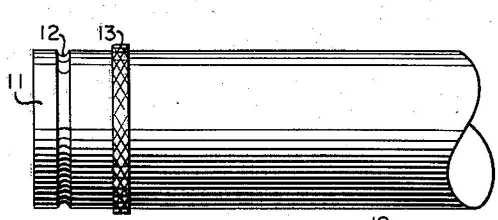


FIG. 5

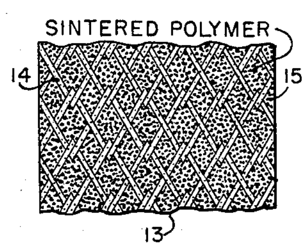
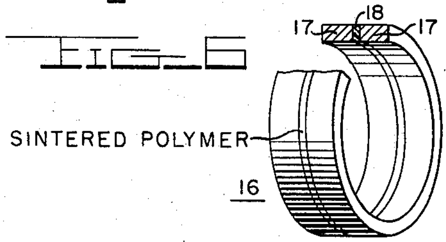


FIG. 6



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1

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PROJECTILE ROTATING BAND

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3 Claims. (Cl. 102—93)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to ammunition, more particularly to an improvement in projectiles which is designed to increase the firing life of gun barrels.

Metal fouling, if unchecked, will eventually terminate the firing life of gun barrels. It is caused by the deposition of softer metal from the projectiles on to the rifling of the gun during firing and by accumulation produces a roughened surface on the rifling which is reflected in deviations in the spin imparted to the projectile and thereby loss in accuracy in the gun fire. Loss in muzzle velocity of the projectile may also result from metal fouling. To overcome this metal fouling, the earlier jacket of cupro-nickel on bullets and rotating band of soft copper on artillery type projectiles have been generally replaced by those made of the harder, but still necessarily relatively soft, gilding metal. For single shot weapons, this measure has all but eliminated metal fouling. It has not, however, met with equal success in the case of rapid fire guns, especially those which are automatic, where metal fouling is still a problem.

We have found that the firing life of gun barrels of all calibers can be materially increased by so modifying the projectile that the portion of its surface which normally makes contact with the rifling of the gun on firing is at least in part essentially sintered polytetrafluoroethylene. Polytetrafluoroethylene is a polymer known in the trade as Teflon. By so modifying the projectile, there eventuates, on firing of the gun, a system of contact between the projectile and the rifling which is not metal-to-metal but polymer-to-polymer. This flows from the fact that sintered polymer is transferred from the projectile to the rifling by rubbing to form on the latter a thin coating or film of the sintered polymer. The coating on the rifling does not build up by accumulation to an undesirable degree of thickness due to the non-self-adhering property of the sintered polymer, the thickness of the coating being that of the thin film as initially applied by the transfer from the projectile. When breaks occur in the film, renewal of the open portions is effected in the same manner; the exposed metal portions of the rifling receiving sintered polymer by transfer from the subsequently fired projectile. A reverse arrangement in which the rifling is coated with sintered polymer and the projectiles are of the usual construction is impractical since movement of the projectile over the rifling will remove portions of the coating until eventually it is worn off.

Among the beneficial results flowing from the presence of the sintered polymer on or as that portion of the surface of the projectile which contacts the rifling of the gun, is the absence of metal fouling. Another beneficial result is reduction in the rate of wear of the gun barrel by friction, the sintered polymer having a low coefficient of friction. A further beneficial result and one of importance to rapid fire guns, especially those which are

2

automatic, is reduction in the occurrence of heat erosion of the gun barrel. The sintered polymer has a low thermal conductivity and this property in the polymer film on the rifling serves to delay transfer of heat from the hot, high temperature gases to the metal of the surface of the gun bore and by consequence, promotes discharge of a greater portion of the heat from the gun barrel by way of the muzzle. Another beneficial result is a greater degree of freedom from firing debris in the gun barrel, the sintered polymer surface on the projectile having the remarkable property of cleaning the gun barrel. Still another beneficial result is a tendency to give a greater muzzle velocity for the projectile. Yet another beneficial result is elimination of the need of oiling the projectile with consequent avoidance of pick-up of dust and sand by the oil.

Modification of the projectile in accordance with the present invention may be done under several forms depending upon the type of projectile. The most general of the forms is a thin film of the sintered polymer over the surface of the projectile including that of the rotating band in the case of artillery type projectiles. A particular form of modification is employed in the case of projectiles of a metal of low melting point, e.g., a lead bullet, since a coating of the sintered polymer cannot be successfuly applied thereto. For such projectiles a preformed insert of the sintered polymer is made an integral part of the projectile. In the case of artillery type projectiles modification of the projectile can be also effected by the provision of a rotating band which in its construction embodies in the periphery thereof a surface which is essentially sintered polytetrafluoroethylene. Modification of the projectile in the several ways described above is illustrated in the accompanying drawing which forms part of the description of the present invention. The thickness of the sintered polymer coating and the reach of the rotating band beyond the periphery of the body of the projectile has been exaggerated in the drawing in each instance for purposes of illustration.

In the drawing:

Figure 1 shows a small arms projectile of low melting point metal modified in accordance with the invention through the inclusion of an insert of sintered polytetrafluoroethylene, the periphery of which forms part of the surface of the projectile,

Figure 2 shows a small arms projectile of high melting point metal modified in accordance with the invention by the presence thereon of a thin film of the sintered polymer,

Figure 3 shows an artillery type projectile modified in accordance with the invention by the presence thereon, including the rotating band, of a thin film of the sintered polymer,

Figure 4 shows an artillery type projectile, partly broken away, modified under another form in accordance with the invention through the provision of a rotating band of a new construction which contains sintered polytetrafluoroethylene as part of its periphery,

Figure 5 is a view in detail of a section of the new rotating band shown on the projectile of Figure 4,

Figure 6 is a view, partly in cross-section, of another new rotating band for the modification of artillery type projectiles in accordance with the invention, the new band also containing sintered polytetrafluoroethylene as part of its periphery, and

Figure 7 shows yet another new rotating band for the modification of artillery type projectiles in accordance with the invention, this new band being of the type shown in Figure 4.

Referring to Figure 1, the projectile 1 of low melting point metal is a lead bullet which contains as an integral part thereof, a washer 2 of sintered polytetrafluoroethylene. A coating of the sintered polymer cannot be successfully applied to low melting point metals because of the high temperature necessary for sintering of the polymer. The washer 2 is located in the bullet just behind the ogive and is conterminous with the adjacent or bearing surface of the bullet. A suitable thickness of the sintered polymer washer 2 is on the order of .025 inch for all small arms bullets, regardless of caliber. As illustrated, the composite bullet of the invention is for a .30 caliber rifle.

The new composite bullets may be made by casting in bullet molds in the usual way with the modification that the washer 2 of the sintered polymer is previously placed in the predetermined position in the mold cavity. The hole in the washer 2 of sintered polymer should be large enough to allow the molten, low melting point metal, such as lead or one of the usual lead alloys, to flow through and fill the bottom as well as the upper portion of the bullet mold cavity, whereby on cooling the casting embraces the washer of sintered polymer as an integral part of the bullet. The washer 2 can be formed by cutting from a tape of the sintered polymer of the required thickness, the outer diameter of the washer being that of the bullet. The washer is dropped into the mold cavity to lie in a horizontal position and is located at the proper level by virtue of the convergence of the walls of the mold cavity which are tapered to form the ogive of the bullet.

In Figure 2 the projectile is a steel or steel-jacketed bullet 3 which for purposes of illustration is shown as for .30 caliber rifle ammunition. The bullet is provided with the usual cannelure 4 for crimping of the cartridge case thereto. A thin film 5 of sintered polymer is coated on the steel surface of the bullet which, as shown, preferably extends back only to the forward edge of the cannelure. This limitation on the area covered by the sintered polymer coating is preferred in order to avoid any difficulties which the coating might pose to effective crimping of the cartridge case to the bullet. The thickness of the sintered polymer film 5 is on the order of 0.6 mil which is a practical value and sufficient to provide a thin coating of the sintered polymer on the rifling of the gun as the bullet passes through the gun bore. Bullets of various calibers made of or jacketed with a high melting point metal may be advantageously modified in this manner.

Figure 3 shows an artillery type projectile modified in accordance with the invention and in the manner described above for steel and steel-jacketed bullets. The sintered polymer coating in the case of artillery type projectiles extends over the rotating band. This is essential. For purposes of illustration, the projectile is shown as for 20 mm. ammunition used in automatic rapid fire guns. It is of conventional construction and arrangement and has a steel shell 6 provided with a cannelure 7, a threaded cap section 10 and a rotating band 8 of gilding metal. The thickness of the sintered polymer film 9 is on the order of 0.6 mil which is also a practical value for the coating on artillery type projectiles of all calibers.

In Figure 4, the artillery type projectile is modified in accordance with the invention thorugh a new rotating band. The projectile 11 is the same as that shown in Figure 3, the shell being made of steel and having a cannelure 12. The rotating band 13 is formed of a three-dimensional, helically woven wire mesh which has been filled with sintered polytetrafluoroethylene. The detail of a section of the new rotating band shown in Figure 5 depicts the open weave of the wires 14 and the random covering of the same by the sintered polymer 15 which fills the openings in the metal mesh up to the level of the wires 14. As the projectile is moved through the gun bore, the compressive action of the moving projectile on the rotating band 13 causes transfer of sintered polymer from the band to the rifling of the gun and coating of a thin film of the sintered polymer on the rifling.

To assist in securing the polymer filled mesh band 13 to the body of the projectile, the seat of the retaining groove for the band is roughened in a suitable manner as, for example, by milling, to provide a better grip for the mesh structure of the band. The dimensions for the band and depth of the retaining groove follow usual practice. The rotating band for a 20 mm. projectile, for example, has a diameter of about 21 mm. and a width of about one-quarter inch, and the retaining groove in the body of the projectile has a depth of about three-sixteenths inch.

Suitable stock for making of the rotating bands 13 is a tubular, three-dimensional, helically woven, ductile wire mesh having a density of about 60 to 85% and a pore size of about 10 microns or less. The weave of the tubular mesh stock is such that grainwise, the angle of crossing of the wires is less than 90°. The wires are welded to each other at their crossings which can be accomplished by sintering to effect self-welding. This structure in the mesh gives a rotating band which has low shear in the direction of the longitudinal axis of the gun bore and maximum tensile strength in the direction perpendicular to the rifling of the gun. The low shear along the longitudinal axis allows the band to yield easily in the direction of movement of the projectile over the rifling, whereas the greater tensile strength along the perpendicular axis forces conformity of the surface of the band to the contour of the rifling and affords strong resistance to disintegration of the band by the high centrifugal force exerted in the rotation of the projectile. Tubular mesh stock of the aforesaid kind in which the wire is made of pure iron is available on the market under the trade name Poroloy and used for filter work. Other ductile metals from which the wire may be made are, for example, copper, brass and bronze. The rotating bands are cut from tubular mesh stock which is slightly larger in both inner and outer diameter than those of the retaining groove in the projectile. In width, the bands are cut slightly smaller than the width of the retaining groove. Filling of the mesh bands with sintered polymer can be carried out by placing them in a housing provided with an inlet through which is pumped a thick aqueous suspension of polytetrafluoroethylene, for example, of 85–95% solids concentration, which passes into the mesh bands and is collected therein, and with an outlet for the effluent water. The polymer particles agglomerate in the wire mesh to promote collection therein. The inflow of the suspension is carried on until by the build up of the resistance to the inflow indication is received of the filled-up condition of the bands. Excess polymer is wiped from the surface of the bands in appropriate manner. Excess water is removed to the extent of an air-dried condition of the polymer which can be accomplished by allowing the filled bands to stand at room temperature for several hours. The air-dried filled bands are then heated to effect sintering of the polymer and cooled to form the finished article. The finished band is applied to the projectile by swaging, in which operation the band is compressed to size with flow of the metal mesh laterally to fill the retaining groove in the projectile.

In Figure 6 the new rotating band 16 is of laminar construction in which a pair of metal washers 17 have a matching washer 18 of sintered polytetrafluoroethylene sandwiched therebetween. The diameter and width of the new laminated rotating band and the depth of the retaining groove therefor as well as the arrangement and attachment of the new band to the body of the projectile follow usual practice in the art. For a 20 mm. projectile, for example, the width of the new rotating band 16 is about one-quarter inch, the diameter thereof about 21 mm. and the depth of the retaining groove about three-sixteenths inch. The washers 17 are made of a ductile metal, such as copper or brass, which latter may be gilding metal, and in width are each about four and one-half times that of the sintered polymer washer **18**. The thickness of the sintered polymer washer for the rotating band of a 20 mm. projectile, for example, is on the order of twenty-five thousandths inch which magnitude of thickness is sufficient, also, in the case of the rotating band for 37 and 40 mm. projectiles to provide a coating of the sintered polymer on the rifling of the gun. The washer **18** can be stamped from a tape of the sintered polymer of the required thickness, the outer diameter of the washer being that of the metal washers **17**.

Construction of the new rotating band **16** is accomplished by coating one side of each of the metal washers **17** with a thin film of an aqueous suspension of polytetrafluoroethylene, on the order of 0.2–0.3 mil thick, bringing the film to the air-dried condition, forming a sandwich assembly of the coated metal washers **17** with the sintered polymer washer **18** aligned therebetween and in contact with the air-dried film on the metal washers, and while holding the parts in aligned relationship by means of the application of a light pressure, for example, in a platen type press, heating the assembly to a temperature sufficient to sinter the air-dried polymer film on the metal washers **17** and soften the sintered polymer washer **18**, and withdrawing the assembly and allowing it to cool to set the cementing between the parts.

Figure 7 shows a mesh type rotating band **19** similar in construction to that of Figures 4 and 5 but modified to include a collar **20** which serves to facilitate swaging of the band onto the projectile and to protect the mesh against permanent deformation in the swaging operation. The collar **20** and the mesh **21** are made of the like ductile metal, for example, brass, and the mesh mounted on the metal collar by a self-welding of contiguous portions of the wire to the collar. This composite mesh band is made by helically weaving the ductile wire on a tube of the ductile metal serving as the mandrel. The ends of the woven mesh are closed by flame heating to cause self-welding of the wires and the structure heated to cause sintering of adjacent wires of the mesh to the metal tube and to each other at their crossings. The mesh portion of the band is filled with sintered polymer **22**. Filling of the mesh with polymer can be carried out by placing a rubber sleeve over the tubular structure and through openings in the rubber sleeve, one to each side of the center and a substantial distance toward the respective end, forcing a stream of the thick aqueous suspension of the polymer into the mesh until it is filled. A centrally located hole in the rubber sleeve provides for outflow of the water and excess polymer suspension. After removal of excess polymer from its surface, the filled mesh structure is subjected to air drying of the polymer and sintering of the same. The rotating bands are cut from the finished tubular stock to a width slightly less than that of the retaining groove in the projectile and swaged into the groove which is milled at the bottom to promote retention of the band on the projectile.

Polymer suspensions suitable for use in modifying projectiles in accordance with the invention are low viscosity dispersions of colloidal polytetrafluoroethylene in essentially water as the suspending medium. The particle size of the polymer may be on the order of 0.1 micron. A small amount of a wetting agent is present in the suspension to promote initial dispersion of the polymer particles in the water and to maintain their dispersed condition. In addition to the polymer, the suspension may contain pigments, notably such as contribute to increase in protection against moisture corrosion of the metal. A preferred aqueous polymer dispersion for purposes of the invention is one containing chromic acid, which pigment affords a strong degree of protection to iron and steel surfaces against rusting, especially when the sintered polymer coating thereon is formed of at least two layers of the suspension which have been separately applied and sintered. The second layer of sintered polymer tends to seal-off pinholes in the first layer and thereby reduce the incidence of occurrence of moisture at the surfaces of the metal. Aqueous polymer suspensions to be used for primer or single layer coatings on iron, steel, brass and copper are highly acid. The acidity can be provided by the addition to the polymer suspension of an appropriate acid, for example, phosphoric acid, and in part by the use of an acid-reacting wetting agent for dispersion of the polymer particles in the water. Aqueous polymer suspensions suitable for effecting modification in projectiles in accordance with the invention are available commercially, or described in one or more of the following U.S. Patents: 2,478,229, 2,562,117 and 2,562,118.

The surface of the projectiles, rotating band, wire mesh or metal plates of the laminated type of new rotating band, as the case may be, should be in a clean condition before application of the aqueous polymer dispersion since dust, oil and grease interfere with the adhesion of the polymer suspension to the metal. Any suitable method may be used for this purpose. In some instances, such as in the case of surface of the body of the projectile, washing with unleaded gasoline or other aliphatic hydrocarbon degreasing solvent may be sufficient to clean the surface. Non-ferrous metal surfaces may be cleaned by washing them in a hot water solution of 3% each by weight of trisodium phosphate and Aerosol OT (sodium dioctylsulfosuccinate) after which they are thoroughly rinsed in water and air dried. A satisfactory method for cleaning ferrous metal surfaces is to subject them to a light sand-blasting using a very fine grit, for example, No. 80 silica sand, followed by washing with a volatile aliphatic hydrocarbon degreasing solvent. Handling of the cleaned metal surfaces should be avoided until the wet-coating of the polymer suspension thereon has become air dried since finger marks on the metal surface prevent adhesion of the polymer suspension thereto. Oxide film on the metal need not be removed and, in fact, should be retained since it promotes adhesion of the polymer suspension to the metal.

Coating of the metal rotating bands and, where practicable, of the body of the projectile can be done by dipping or spraying, preferably, however, by spraying which provides better control both in respect to thickness and the evenness of the coating. Spray viscosity in the aqueous polymer suspensions can be had at solids concentration of 50% or less. Small proportions of toluene emulsified in the suspensions improve their flow quality for spraying. The thickness of the coatings can be varied by varying the solids concentration of the suspensions, the lower the solids concentration therein, the thinner the coated layer. Thinning of the polymer suspensions can be done by dilution with distilled water. The sintered polymer has low strength and to improve the adhesion thereof and the availability of the same as a dry lubricant for the rifling of the gun, the surface of the rotating band is roughened, such as by grooving or knurling, before applying the aqueous suspension of the polymer thereto.

Concentration of aqueous polymer suspensions for the purpose of obtaining high solids content suspensions for the filling of wire mesh type rotating bands can be accomplished by freezing the polymer suspension, thawing them and during the thawing removing the water by decantation or any other way found suitable to leave an aqueous paste having a solids content on the order of 85 to 90%.

It is essential that excess water be removed from the wet polymer coatings on the projectile or rotating band, etc., before sintering in order to avoid blistering or void formation in the sintered coatings. The coatings are therefore brought to air dried condition before the sintering. To accomplish this, the coatings are allowed to stand at room temperature until air dried, for which generally about two to three hours will suffice depending upon the humidity of the atmosphere. Some acceleration of the drying may be practiced by subjecting the wet coated articles to warm air at a temperature below 100° F. in an oven of the convection heating-recirculating air type.

Sintering of the air dried polymer present as a coating on the projectile or on the rotating band or on both, or as the filling in the wire mesh type band or as the adhesive on the metal washers of the laminated type band is carried out in accordance with known practice by heating the articles to a temperature between about 675 and 750° F., preferably at about 700° F. The heating may suitably be carried out in an electrically heated oven of the air recirculating type. The time required for the sintering is almost entirely determined by that necessary to bring the metal of the articles to temperature, since the actual sintering of the polymer takes place within a matter of a few seconds once the metal reaches sintering temperature. The occurrence of sintering can be visually determined by observing a wet condition of the polymer surface and coalescence of the incipiently fused polymer particles to a continuous mass.

Since the invention described herein may be variously practiced without departing from the spirit and scope thereof, it is not intended that it be limited except as is required by the appended claims.

What is claimed is:

1. A rotating band for projectiles comprising a ring of porous, three-dimensional, helically woven ductile wire mesh having an angle of wire-crossing, grainwise, of less than 90°, the ductile wires welded to each other at their crossings, a density of from about 60 to 85%, a pore size of about 10 microns and less and filled with essentially sintered polytetrafluoroethylene.

2. A rotating band for projectiles comprising a ring of porous, three-dimensional, helically woven ductile wire mesh having an angle of wire-crossing, grainwise, of less than 90°, the ductile wires welded to each other at their crossings, a density of from about 60 to 85%, a pore size of about 10 microns and less, welded at adjacent portions to a ductile metal collar and filled with essentially sintered polytetrafluoroethylene.

3. A projectile provided with a rotating band thereon which comprises a ring of porous, three-dimensional, helically woven ductile wire mesh having an angle of wire-crossing, grainwise, of less than 90°, the ductile wires welded to each other at their crossings, a density of from about 60 to 85, a pore size of about 10 microns and less and filled with essentially sintered polytetrafluoroethylene.

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