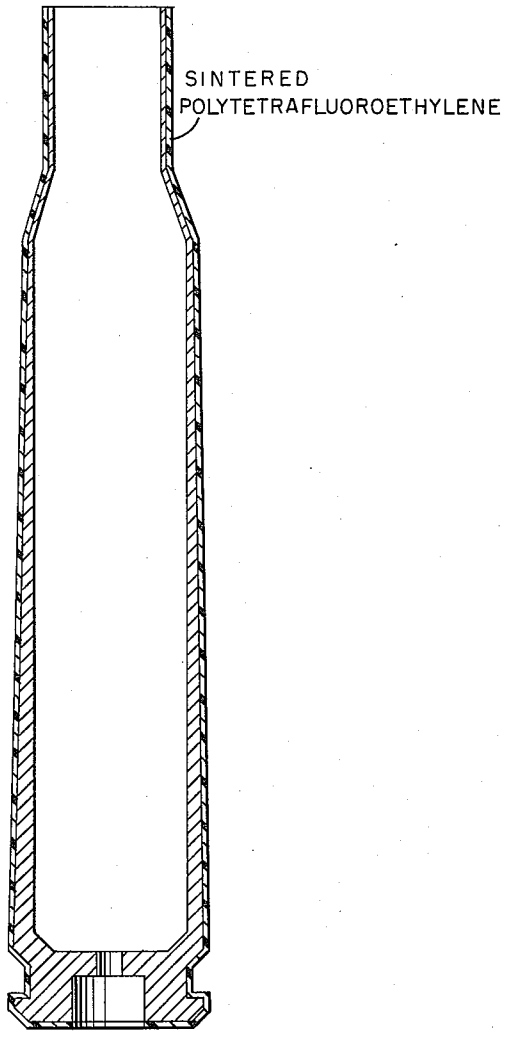
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AMMUNITION CARTRIDGE CASES

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AMMUNITION CARTRIDGE CASES

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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 an improvement in ammunition, more particularly to improved cartridge cases for ammunition used in automatic rapid fire guns.

Automatic rapid fire guns as herein referred to has reference to guns which are fully automatic in contrast to semi-automatic guns and includes automatic guns operated by percussion control such as the automatic rifle and automatic guns operated by electrical firing apparatus such as the automatic machine gun. The cartridge for the automatic rifle is usually caliber .30 and for the automatic machine gun usually caliber .50 and 20, 37 and 40 mm. As is customary, the casing of the cartridge is considerably thicker in section in the base or primer portion than in the wall and generally, although not necessarily, has a shoulder at the base of the neck portion.

A number of difficulties in the operation of automatic rapid fire guns can be expected to arise from the action of the cartridge case in the gun chamber after firing. It is accepted practice to design the gun chamber of automatic rapid fire guns so as to provide some clearance or looseness of fit between the cartridge case and the wall of the gun chamber whereby to prevent gun malfunction caused by variations in the cartridge size and by variables involved in the time-position relationship of the gun and feed mechanisms. It is this designed clearance which is the source of the difficulty to be experienced with unlubricated cartridges, since the cumulative effect of the tolerance and of the elastic deformation of the gun during firing will often cause large and unpredictable clearances to exist between the face of the breechblock and the face of the gun chamber. Such clearances, if large, may result in rupture of the cartridge case and jamming of the gun. When an unlubricated round is fired, the neck of the cartridge case will expand by reason of the heat contained in the casing until it is held immovably against the chamber wall by the developed gas pressure. At the same time, the breechblock will be displaced from the cartridge head, leaving the cartridge case unsupported at the rear. The cartridge case thus has space within which to stretch. If this clearance be great enough, the stretching due to the back pressure in the casing will exceed the elastic limit of the brass or steel of the casing and result in rupture of the casing. Gun malfunctions which have been caused by this condition include in addition to split cartridge cases, slow rates of fire, failure to extract the cartridge case and telescoped rounds. With high explosive-containing projectiles, a blown-up gun may result. An additional problem in the form of a simultaneous expansion and stretching of the cartridge case may be presented in the case of automatic rapid fire guns in which the contour of the cartridge case and of the gun chamber are different. In such case, a narrow highly stressed area will be developed in the wall of the cartridge near the end of the casing and with an excessive head space

left by movement of the breechblock, rupture of the casing will invariably occur in the absence of a lubricant on the cartridge.

It has been recent practice to lubricate ammunition for aircraft mounted 20 mm. automatic rapid fire guns with oil or grease to obtain improved operation of the gun through decrease in jamming and icing. While the measure has been a success from the standpoint of lubrication, it has brought with it serious maintenance troubles. A lubricating coating of oil or grease on the cartridge case provides a medium for the pick-up and retention of dust, deposits from blown-back gases, sand and moisture. Dust and sand adhering to the cartridge case may cause abrasion and jamming of the gun and feeder mechanism and excessive wear of the gun barrel. Accumulated dispersed or emulsified water on the cartridge case sometimes thickened rapidly in cold weather and invited icing troubles. A high viscosity oil is used for lubrication of the cartridges in order to avoid rapid drainage. This oil through blow-back accumulates in the gun mechanism where it blends with the low viscosity oil used for lubrication of the gun mechanism to produce a mixed oil of undesirably higher viscosity from which operational difficulties develop at low temperatures. A further disadvantage is that oil or grease must be applied to ammunition at a time as close to firing as possible because of difficulties arising from draining and evaporation of oil, uneven distribution of grease and accumulation of dust and water on the oiled or greased surface. While oiling of ammunition has been satisfactory in some respects, the time and labor required to lubricate ammunition just after belting prior to mounting in the plane is a military drawback. Wax coating of ammunition is only partially successful due to plastic flow of wax and adhesion between cartridges during storage prior to belting and to accumulation of dirt. The problem of coating and storing waxed ammunition has always been a nuisance and at times has proved costly. Up to the present no wholly satisfactory solution to the problem of lubricating ammunition has been found.

Observations made during single round firing of a 20 mm. automatic machine gun indicated that the problem of lubricating ammunition for automatic rapid fire guns is not simply one of overcoming sliding friction in the usual sense but of preventing seizure or binding between the neck of the cartridge case and the wall of the gun chamber so that the casing may be free to move rearwardly under the gas pressure and maintain contact with and derive support from the face of the breechblock. Firing tests have demonstrated that the neck and shoulder of the cartridge case are the critical areas to be lubricated. Casings without shoulder have only the neck as the critical area.

Another difficulty associated with the cartridge case in automatic rapid fire guns is the hazard known as "cook-off" which is the accidental firing of the gun by heat-detonation of a chambered round or rounds. Occurrence of this hazard is due to excessive heat build-up in the gun chamber. Automatic rapid fire guns by reason of their cyclic fire rapidly develop a large amount of heat. Part of this heat is constantly being transferred through the metal of the cartridge case to the gun chamber which in a short time becomes very hot. The gun chamber of automatic rapid fire guns always contains a live round or rounds and on interruption of firing with an excessive heat build-up in the gun chamber, heat detonation of chambered ammunition has been known to occur. This accidental firing is especially dangerous when the round contains a high explosive for in such case it means bursting of the gun. Where the gun is mounted on a plane and is equipped with a revolving firing chamber, chambered rounds not in firing position which have been heat-detonated may cause damage to the plane.

We have found that the aforementioned difficulties in the operation of automatic rapid fire guns can be eliminated or in substantial measure reduced by modifying the exterior surface of the cartridge case to present to the wall of the gun chamber, a surface which is essentially sintered polytetrafluoroethylene. This is accomplished in accordance with our invention by coating the exterior surface of the cartridge case with a thin film formed essentially of sintered polytetrafluoroethylene. An effective range of thickness for the sintered polymer coating is on the order of 0.2 to 0.6 mil. The thin coating may consist of a single layer or of several layers of the sintered polymer. Polytetrafluoroethylene is a polymer known in the trade as Teflon.

Illustrative of the improvement in ammunition for automatic rapid fire guns which can be made in accordance with our invention is the coated cartridge case shown in cross-section in the single figure of the accompanying drawing. The cartridge case there shown is for 20 mm. ammunition and is typical of the type of ammunition with which the present invention is concerned. The coating of sintered polytetrafluoroethylene is shown in exaggerated thickness on the cartridge case for the purpose of clarity in reading the drawing.

The sintered polymer coating has a very low coefficient of friction. This property of the coating coupled with its capacity to flow under the pressure conditions obtaining when the cartridge case is thrust forward in the gun chamber effectively prevents locking or binding between the neck of the heat expanded cartridge case and the steel wall of the gun chamber. These properties in the dry lubricant coating are preserved by virtue of the good adhesion of the sintered polymer to the metal of the case and its stability to the heat developed in the firing of the gun. The coating on the cartridge case results in a system in which, under the conditions obtaining in the gun chamber after firing, the surfaces in contact at the neck portion of the cartridge case are no longer those of metal-to-metal but of polymer-to-metal with the resultant that the case is free to move backward to its designed position in the gun chamber without incurring permanent stretching or undergoing splitting or rupture. From its normal position the cartridge case is freely ejected on opening of the breechblock by the residual gas pressure developed in firing. So effective is the sintered polymer coating to prevent binding of the cartridge case to the wall of the gun chamber that tests in which the rounds were fired under the adverse condition of high lock clearance in a clean dry gun chamber showed no permanent stretching of the case to have occurred, and, resultantly, no splitting or rupture of the same. The effectiveness of the sintered polymer coating to act as a dry lubricant or in the nature of an anti-seizing agent for the ammunition through its low coefficient of friction and plastic flow at firing temperatures is also retained by virtue of its high resistance to abrasion, cracking and embrittlement over a temperature range from —70 to 500° F. and by the absence of melting or pronounced softening at temperatures up to 500° F.

The use of the sintered polymer coating on cartridge cases for ammunition to be used in automatic rapid fire guns eliminates the need for oiling or greasing the ammunition and by consequence avoids introduction of dust, sand or water into the gun or feeding mechanism which in the past has been found to be associated with oiled or greased ammunition. The adhesion of the surface of the sintered polymer coating to dust, dirt or sand is practically nil. Dust, dirt and sand and particles of blown-back debris from the firing of cartridges can be expected to act as points or nuclei on which moisture will condense whereby under low temperature operating conditions an icing hazard in the breechblock and receiver sections of the gun will be created. The sintered polytetrafluoroethylene coating will not present this hazard since blown-back debris from the sintered polymer, of which little is formed, is as highly water-repellent as wax. This high water-repellency or low wettability of the surface of the sintered polymer coating also serves to minimize retention of moisture on the cartridge case due to rain, fog or high humidity.

The sintered polymer is effective to provide the metal of the casing with good protection against corrosion by fresh water, using a single layer film for brass and a double layer film for steel. It is also effective to provide good protection against salt water corrosion for which purpose a double layer film on the metal of the cartridge case is preferred.

A further advantage of the improved ammunition of the invention is that for the first time it makes possible, as a generally practicable matter, prebelting of ammunition for automatic rapid fire guns with consequent attendant saving in valuable time and labor of personnel in the combat zone. In contrast to the but partially successful practice of using wax-coated ammunition for prebelting, in which plastic flow of the wax under warm conditions and adhesion between the ammunition rounds has been encountered, the sintered polymer coating is place-stable and presents a non-self-adherent surface which eliminates sticking of the rounds to one another. The storage of sintered polymer coated ammunition presents no difficulty in respect to temperature conditions as does wax coated ammunition.

The thin sintered polymer films are very effective thermal insulators. This valuable property in the coatings has been found effective to reduce the hazard of "cook-off" after interruption of firing of automatic rapid fire guns. The low thermal conductivity of the sintered polymer coating on the cartridge case serves to materially reduce the rate of transfer of heat from the interior of the empty cartridge case to the wall of the gun chamber whereby the heat build-up in the gun chamber is substantially lowered and chambered rounds are less likely to be exposed to sufficient heat to detonate them.

The sintered condition of the polymer is essential to its success as an effective coating on the ammunition. Sintering of the polymer produces a continuous, strongly adherent coating on the metal which resists abrasion and thermal breakdown and thereby promotes its retention on the cartridge case to perform the aforementioned highly useful functions in the operation of automatic rapid fire guns. Air-dried polytetrafluoroethylene coatings and such as are baked at low temperatures, i.e., at temperatures below those which will produce sintering of the polymer, are unsuitable since the coatings are too porous, lack adherence to the metal of the cartridge case, have little resistance to abrasion, and are subject to thermal decomposition at the temperatures existing in the gun chamber on firing. Firing tests have shown that there is a destructive heat transfer through the air-dried and low temperature baked coatings with excessive transfer of decomposed polymer to the gun chamber. Residue from the decomposed polymer appeared on the ejected cartridge case, which uncleanliness is alone sufficient reason for rejecting air-dried and low temperature baked polymer coatings as ammunition lubricants.

The polymer coatings are applied to the cartridge casings by a series of steps involving application of a thin coating of the aqueous polymer suspension to the clean metal surface, air drying the wet coating and heating the air dried coating to sinter the polymer. In the case of plural layer coatings, the succeeding layers are each individually air-dried and sintered.

Polymer suspensions suitable for use in producing the coated cartridge cases 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 wetting agent is used in small amounts in the suspensions to promote initial dispersion of the polymer particles in the water

and to maintain their dispersed condition. In addition to the polymer, the suspensions may contain pigments, notably such as contribute to increase in protection against moisture corrosion of the metal, for example, chromic acid. Those dispersions in which the only solid is the polymer particles give a clear, transparent finish in the sintered polymer. Aqueous polymer suspensions used for primer or single layer coating of steel or brass casings are highly acidic. The acidity can be provided by addition 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. Slightly alkaline suspensions of the polymer are used for coating aluminum casings, suitably an aqueous dispersion of the polymer containing caustic soda and, as the wetting agent for dispersion of the polymer particles, the sodium salt of the sulfuric acid ester of a mixture of long chain alcohols, the chain length of which corresponds to that of the cocoanut oil fatty acids and predominantly is composed of lauryl alcohol. Aqueous polymer suspensions suitable for use in producing the coated casings of the present invention are described in one or more of the following U.S. patents: 2,478,229, 2,562,117 and 2,562,118. Suitable aqueous polymer suspensions are available commercially.

The surface of the cartridge cases is put in clean condition prior to applying the aqueous polymer suspension thereto since dust, oil and grease interfere with the adhesion of the polymer suspension to the metal. One method found suitable for cleaning non-ferrous cartridge casings is to wash them in hot water containing in solution 3% by weight each 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 casings 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, such as unleaded gasoline, and air drying. Handling of the cleaned cartridge casings is to be avoided until after the wet coating has air dried since finger prints on the metal surface prevent adhesion of the polymer suspension. Oxide film on the metal need not be removed and, in fact, should not be since it promotes adhesion of the polymer suspension to the metal. Where electrolytic cleaning or acid cleaning is employed to prepare the metal casing prior to coating with the polymer suspension, it is recommended that such casings be exposed to heating at 700° F. for a period sufficient to drive off any occluded gases and to provide a thin oxide film on the surface of the metal. This treatment of the metal casing will promote excellent adhesion of the polymer suspension and improve rust protection for steel surfaces through a reduced porosity in the sintered coating.

Application of the aqueous polymer suspensions to the cartridge casings may be done by dip coating or by spraying. Preferably it is done by spraying which affords better control both in respect to the thickness and evenness of the coating. For spray coating, the cartridge casings may be frictionally mounted on a spindle extending through the hole for the primer in the bottom of the casings and the casing rotated at a moderate speed into a spray of the aqueous polymer suspension delivered at a predetermined rate from a hand operated or automatic ionizing spray apparatus. Spray viscosities in the aqueous polymer dispersions can be had at solids concentrations of 50% or less. Small proportions of toluene emulsified in the suspensions improves their flow quality for spraying. The thickness of the coatings can be varied by varying the solids concentration of suspensions, the lower the solids concentration, the thinner the coated layer. Thinning of the polymer suspensions can be done by dilution with distilled water.

The wet coating on the cartridge casings is air dried by standing at room temperature before being subjected to sintering. From two to three hours, depending on the humidity of the atmosphere, will generally suffice to bring the coating to the air dried condition. Some acceleration of the drying may be practiced by subjecting the wet coated casings to warm air at a temperature below 100° F. in an oven of the convection heating-recirculating air type. It is essential that sufficient water be removed from the coatings to avoid blistering or void formation on sintering.

Sintering of the polymer coating on the cartridge casing is carried out at a temperature between about 675 and 750° F. The choice of means to be used for heating the coated cartridge casings to sintering temperatures will depend upon the metal of the casing. Polymer coated steel casings are sintered in an oven, suitably in an electric oven of the recirculating air type. Polymer coated brass and aluminum casings, on the other hand, will soften under the effect of the relatively long exposure to high heat involved in oven heating with serious loss in structural strength of the metal. For these casings, the metal of which has a softening point below the sintering temperatures for the polymer, a surface type heating is used for the sintering in which the coated casing is heated to temperature by means of a radio frequency heater having a coupling coil of special design. The coupling coil is formed of a single ring having its inner surface tapered to form a peripherally extending knife-edge of slightly greater diameter than that of the largest outside diameter of the casing. The coated brass or aluminum casing is passed through the coupling coil in a matter of seconds in which time only a small area of the polymer coating is successively exposed to the high sintering temperature due to the vary narrow heating surface of the knife-edge. By immediate quenching of the heated casings in water, for example, in water at 60° F., the strength of the metal is retained with but slight loss to obtain coated casings which in terms of Vickers hardness correspond approximately to the new, non-coated cartridge casings. The quenching step has the additional advantage of acting to strengthen the freshly sintered polymer and thereby produce a more durable coating on the casings. This advantageous measure can be applied to produce more durable sintered polymer coatings on the cartridge casings regardless of the nature of the metal of the casing.

The occurrence of sintering in the polymer coatings 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. Color change can also be availed of as an indicator of sintering. A coating from an aqueous suspension of the polymer which is without addition of pigment goes from the milk-white appearance of the air dried coating to a clear, transparent condition in the sintered coating. A coating from an aqueous suspension of the polymer which contains chromic acid as the pigment changes from a green in the air dried coating to a gray-green in the sintered coating. A control can be set up for determining sintering of the polymer for coatings other than those from a non-pigment polymer suspension by the use in the oven of a cartridge casing coated with non-pigment polymer suspension. Observation of the clear condition of the sintered polymer coating on the control casing visually indicates sintering of the polymer coating on the other casings. This same type of control can be employed for the radio frequency sintering of polymer coated casings. In such case, the control cartridge is used to indicate the length of time of pass of the air dried polymer coated cartridge cases through the coupling coil. Where plural layer coatings are involved the control cartridge is modified to the extent that it carries the identical layer or layers of sintered polymer as the coated cartridge casings to be subjected to the sintering step.

The time required for carrying out the sintering step is almost entirely determined by that necessary to bring

the metal of the cartridge casings to temperature since the actual sintering of the polymer takes place within a matter of seconds after the casing reaches sintering temperatures. Where the sintering is done by heating in an oven, the heating time, aside from factor of starting temperature and oven heating efficiency, is determined almost solely by the weight and thickness of the metal of the casings. An average heating time for sintering a 0.1 to 0.3 mil thickness single layer polymer coating on a standard 20 mm. steel cartridge casing is from about 5 to 6 minutes with a starting and heating temperature for the oven of 700° F. Under these same heating conditions, an average heating time for sintering of a second layer of polymer of 0.3 to 0.4 mils thickness applied to the sintered first layer to form a double coating on the steel casing will be from about 15 to 20 minutes, the longer heating time required for sintering of the second polymer layer being due to the thermal insulating effect of the sintered first layer whereby heat transmission from the hot metal casing is delayed. In the case of radio frequency heating of the coated cartridge casings, the heating time is much shorter since only the surface of the metal casing is brought to sintering temperatures. For a standard 20 mm. brass cartridge casing coated with a single polymer layer of from 0.2 to 0.5 mils thickness, an average heating time for sintering at 750° C. (400 kc. power supply) is about 5 to 7 seconds and for a second layer of a double coating thereon, about 15 to 20 seconds.

The modification of the surface of cartridge cases for good results regardless of the caliber of the ammunition. ammunition as described herein is applicable with equally A single layer coating of the sintered polymer as described hereinabove in a thickness of from about 0.2 to 0.6 mils can be used on the cartridge cases to obtain remarkable improvement in the operation of automatic rapid fire guns. It is advisable, however, in the case of steel cartridge casings to double coat the same to provide protection to the steel against corrosion by prolonged exposure to moisture. A double coating in which the first sintered polymer layer contains chromic acid as a corrosion protecting pigment and is from 0.1 to 0.3 mils thick and the second layer is a clear sintered polymer finish of from 0.3 to 0.4 mils thick has been found satisfactory for the purpose. Of course, the coating in all instances can be formed of a plurality of layers of the sintered polymer, successively applied.

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 metal cartridge case for ammunition of a caliber used for automatic rapid fire guns in which the exterior surface of the cartridge case is a continuous thin film of low thermal conductivity providing lubrication for the cartridge case, said film being of a thickness not substantially exceeding 0.7 mils and consisting essentially of bonded, sintered polytetrafluoroethylene free from metallic particles.

2. A metal cartridge case for ammunition of a caliber used for automatic rapid fire guns in which the exterior surface of the cartridge case is a continuous thin film of low thermal conductivity providing lubrication for the cartridge case, said film being of a thickness not substantially exceeding 0.7 mils and consisting essentially of bonded, sintered and quenched polytetrafluoroethylene free from metallic particles.

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