Sept. 15, 1964

D. E. JACOBSON ET AL

3,148,620

WEAR REDUCTION ADDITIVES

Filed May 29, 1961

2 Sheets-Sheet 1

Fig. 1

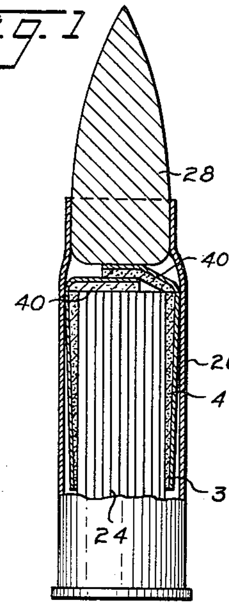



Fig. 2

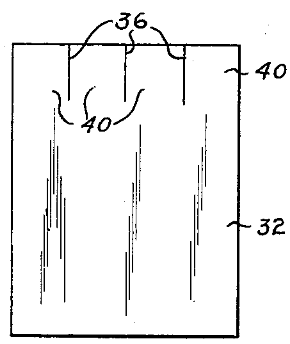
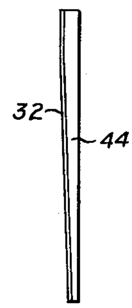
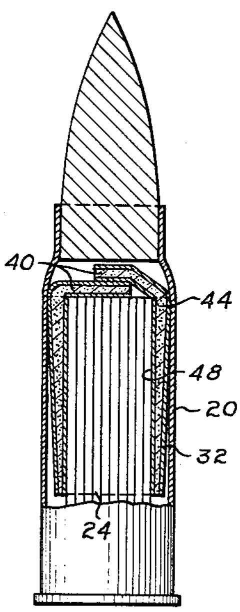



Fig. 3



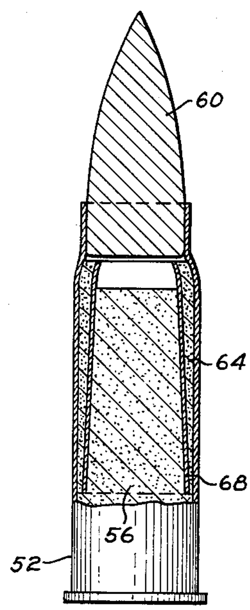




Fig. 6

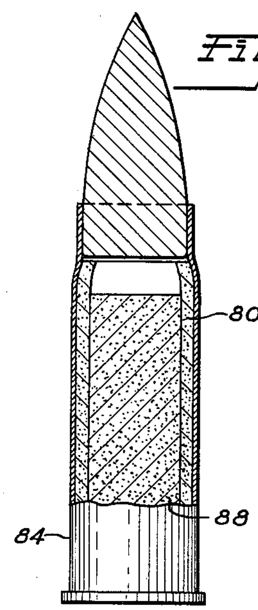



Fig. 4

Fig. 5

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Fig. 7

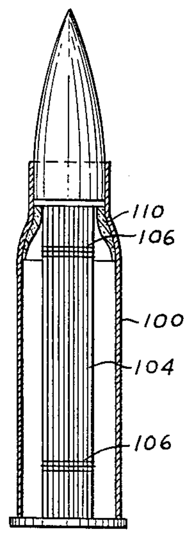



Fig. 8

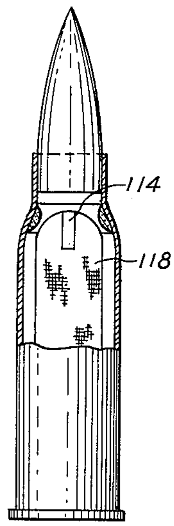



Fig. 9

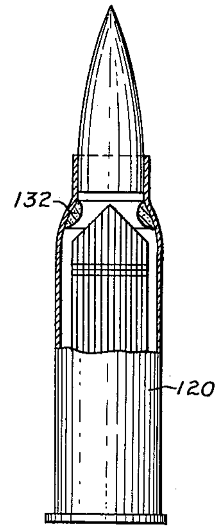



Fig. 10

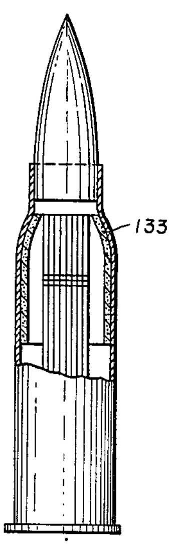



Fig. 11

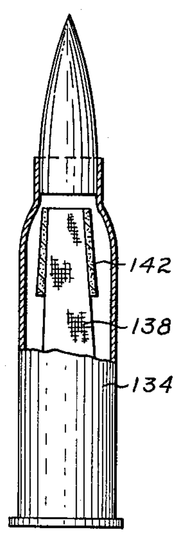
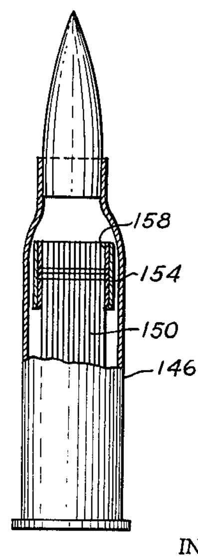



Fig. 12

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# WEAR REDUCTION ADDITIVES

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Filed May 29, 1961, Ser. No. 126,747
Claims priority, application Sweden Aug. 14, 1959
31 Claims. (Cl. 102—38)

This invention relates to compositions, and methods of applying the compositions, for reducing erosion in a member subjected to hot flowing gases. More particularly, the present invention provides compositions and methods of reducing wear normally attendant with the use of known propellant charges in firearm barrels, and the description of the invention is here made in connection with this function. By cartridge is meant a case, capsule, shell or bag holding a propellant charge for a firearm; in small arms and some guns the cartridge also includes the projectile.

This application is a continuation-in-part of our two copending applications Serial Nos. 46,008 and 46,009, filed July 28, 1960. Application Serial No. 46,009 is now abandoned.

Certain of the concepts and of the subject matter disclosed in this application but not claimed herein are claimed in applicant's copending application Serial No. 377,278 filed June 23, 1964.

The problem of excessive barrel wear has existed throughout the history of firearms; however, it is today particularly critical due to the more powerful propellant charges in modern cartridges. For example, the present life expectancy of a gun barrel may be 250 rounds, after which time it must be replaced. This has the obvious disadvantage of impairing accurancy of the gun after several firings and also necessitates removal of the gun from service for the period of barrel replacement. By using the additive compositions of the present invention it has been discovered that the life of a barrel having reasonable accuracy may be extended for the practical life of the gun in some instances; e.g., instead of being limited to 250 rounds, the capacity of a gun barrel may be increased to accurately firing 2000 or more rounds. The cause of barrel wear is not fully understood, but it is thought to be due to melting, softening or chemical or physical deterioration of the barrel surface on firing, and a subsequent partial erosion of this soft layer by the outflowing combustion gases.

Briefly, barrel wear is reduced by the preferred embodiments of the present invention by incorporating in the cartridge, a first material which upon firing of the cartridge will inhibit temperature and erosion wear on the gun barrel surface. It is thought this is accomplished by forming an erosion resistant layer on the barrel surface when the cartridge is fired. Optionally a second material may be advantageously included which will produce gases relatively cool in comparison with the hot products of combustion of the main charge and which act to insulate the barrel forming a cool gaseous layer between the hot propellant gases and the barrel. The materials may be utilized with any conventional propellants to reduce the normal wear effects produced thereby.

Prior attempts to offset the deleterious effects of propellant charges on firearm barrels have included the use of ammonium carbonate in a cartridge as disclosed in U.S. Patent No. 1,187,779 to Patten to produce relatively cool gases for surrounding the products of combustion of the main propellant charge and thereby protecting the barrel wall from the high temperature effects of such products. U.S. Patent No. 2,131,353 to Marsh discloses various additives for smokeless powder for forming a deposit in the gun bore to protect the latter against the rusting effects of humidity and the residual products of combustion of the powder remaining in the barrel, but not against, the erosive effects caused by the combustion gases during firing. Therefore, while it has been proposed to form a rust resistant deposit and also to produce cool gaseous barrel insulation, the present invention provides protection against wear on metal members superior to prior art methods. Thus, this invention for the first time contemplates forming temperature and erosion resistant inhibitors to extend the life of firearm barrels and other metal members subjected to hot flowing gases. Moreover, this invention also provides gaseous insulation layers superior to such insulation disclosed by Patten by using more efficient materials, and in a much simpler and more economical manner as will be described hereinafter.

Accordingly, it is an object of this invention to reduce the amount of wear in a member subjected to hot, rapidly flowing gases.

It is another object of this invention to reduce the erosion in a metal member such as a firearm barrel by incorporating erosion preventative material in the firearm cartridge.

It is still a further object of this invention to reduce wear on a metal member by incorporating material in a cartridge which will form, a temperature and erosion resistant layer, cool insulating gases, or both.

Another object of this invention is to provide novel arrangements of an additive layer with respect to a propellant charge.

A further object of this invention is to provide additive materials for reducing wear in a gun barrel which are applied in a cartridge, around the propellant charge by being secured either to the inner wall of the cartridge case, to the textile or other like bag containing the propellant charge, or directly to the charge.

Still another object of this invention is to provide an additive layer for a cartridge which is simply and economically applied and which is retained in position by a suitable securing means.

A special advantage of the cartridge of the invention is the unchanged characteristics of the internal ballistics compared with the untreated charge. We have for instance found that the muzzle velocity and pressure are unchanged.

Further objects and advantages will become apparent to those skilled in this art from the appended claims and following description of the invention and exemplifications thereof, made in conjunction with the accompanying drawings showing preferred exemplary embodiments and wherein:

FIGURE 1 is a front elevation view, partly broken away, of a cartridge embodying the preferred additive of the present invention.

FIGURE 2 is a view of an unfolded sheet utilized in the cartridge of FIGURE 1;

FIGURE 3 is a side elevation view of the sheet shown in FIGURE 2;

FIGURE 4 is an elevation view of a cartridge, partly broken away, illustrating a modification of the present invention;

FIGURE 5 is a front elevation view of a cartridge, partly broken away, illustrating another embodiment of the present invention;

FIGURE 6 is a front elevation view of a cartridge, partly broken away, illustrating a further modification of the present invention; and,

FIGURES 7–12 are also elevation views of cartridges partly broken away, illustrating further modifications of the present invention as will be described. It will be appreciated that the drawings herein illustrate diagrammatically the use of additives in accord with the present invention and that the proportions are not necessarily to scale.

It will be understood that the additive may consist of a layer forming material or a cool gas forming material alone. However, in accordance with the preferred embodiment of this invention, an additive is incorporated in a cartridge which it is thought, produces on firing, a temperature and erosion resistant layer on the inner surface of a gun barrel by suspending a layer forming substance in the hot, rapidly flowing gases of the firearm which is capable of combining with the material on the inside surface of the gun barrel. It is believed that the layer is comprised of nitrides, oxides or carbides, and that the layer protects the barrel from and is then partly removed by the hot combustion gases formed by the rear part of the charge. The additive may be applied in several ways, but in general it is preferred that the layer forming substance be dispersed in a continuous layer of the second substance around the propellant charge. By placing the additive substances around the charge a very good cool gaseous insulation layer is obtained and also the first substance will be readily and substantially uniformly carried into contact with the inner barrel surface by the combustion gases. The layer will resist action of the hot gases, and as will be described later, may result in as much as 90% or more reduction in normal wear in the barrel.

The first, or metallic temperature and erosion resistant layer forming substance preferably comprises an element which can form a high melting nitride, oxide, or carbide and is one or more of the following: aluminum, boron, titanium, vanadium, chromium, niobium, tantalum or tungsten. Although it may be possible to use one of these elements by itself in the cartridge, an individual element may have a combustion temperature above that of the hot flowing gases and if used as a powder additive, may actually increase barrel wear. Therefore, it is generally preferable for the layer forming substance to be a compound which contains one or more of the above elements and which does not cause a rise in temperature of the combustion gases.

The following metallic temperature and erosion resistant layer forming compounds have been found to give very good results in cartridges, and it is thought that they may have a similar effect in other members particularly steel members subjected to hot rapidly flowing gases: a salt of aluminum and an inorganic acid, especially aluminum fluoride, hydrated aluminum fluoride ($AlF_3 3H_2O$), potassium titanium fluoride, chromium fluoride, vanadium pentoxide, titanim oxide ($TiO_2$), niobium oxide ($Nb_2O_5$), tantalum oxide ($Ta_2O_5$), and tungsten oxide ($WO_3$).

The second or a carbonaceous carrier material capable of forming relatively cool gas is preferably used to position the metallic erosion resistant layer forming material in place. The carrier invariably contains a substantial amount of carbon i.e., about 30% by weight or more. When the metallic compound or compounds are dispersed in the propellant charge, or placed in the cartridge other than by dispersion in the carrier material, the latter may nevertheless, be employed by itself to render a cooling effect upon firing. Best results have been obtained using wax as a second substance, preferably paraffin (approximately 85% carbon) having a melting point between 50° and 100° C. or ozokerite wax having the same or higher melting point. However, examples, of other very suitable materials are:

Alkyd resin paint (approximately 70% carbon) for example "China-Lack" currently produced by Vorch Bäcksin and Co. of Gothenburg, Sweden.
Plastic (polyethylene, cellulose acetate, nylon, etc.).
Sponge rubber or foam plastic.
Cellulose (approximately 40% carbon).
Celluloid (approximately 30% carbon).
Cellulose enamel.
Grease—Any lubricating grease such as petroleum jelly (e.g. petrolatum), a petroleum or synthetic lubricating oil thickened with a metal salt of a fatty acid such as aluminium palmitate calcium palmitate or stearate etc., or an oil thickened with a bentonitic clay and commonly used in lubricated ball valves.
Other waxes such as ceresin and beeswax.
Automobile undercoating compositions—e.g. "Underseal" produced by the Minnesota Mining and Manufacturing Co.

When wax is used, it has been found that in smaller calibre guns, the lower the melting point of the wax, the more effective it is; however, it is difficult from a practical point of view to use a wax having a melting point below 50° C.

On combustion of the charge the following reaction is typical of what occurs to the second substance:

(1) Decomposition of the molecules into their components;

(2) Absorption of heat from the charge by reducing the $CO_2$ and steam in the charge to CO and $H_2$.

$$C+CO_2 \rightarrow 2CO—41,000 \text{ cal.}$$

$$C+H_2O \rightarrow CO+H_2—31,000 \text{ cal.}$$

It is possible that the organic substances mentioned above also reduce wear by mechanically protecting the barrel from the hot combustion gases. It is very difficult to be certain what does exactly occur on firing, but the reduction in wear due to the presence of these substances is significant.

In application of the first and second substances to cartridges, it is preferred that the materials be utilized in combination, as for example a dispersion of the first substance in a layer of the second cool gas forming substance. Very small amounts of the first substance have a beneficial effect while too large an amount may have an adverse effect on the propellant power obtainable in a cartride of a certain size. Generally, the first substance should constitute between 0.01–20% by weight of the propellant charge, and more preferably should be present between .05 and 5% by weight of the charge. The type propellant used introduces only minor variations in test results and the stated percentages are therefore applicable to any conventional single, double, or triple base powder.

It is difficult to establish a fixed rule by which the optimum amount of second substance can be ascertained. There is a minor but somewhat insignificant effect with very thin layer thicknesses, but the effect increases substantially when the layer thickness reaches a certain value. Good results have been obtained by applying a layer in a sufficient thickness of the second substance to the outer surface of the propellant charge, or on its container, preferably on the inner surface of said container, or to the inner surface of the cartridge case.

The part of the layer adjacent the front part of the charge is more effective than the part of the layer adjacent the rear end of the charge: in fact, if the layer extends the whole length of the charge, the rear half of the layer has little effect; and it is the front half, especially the front ⅓, and particularly the front 1⁄20, which has most effect in absorbing heat from that part of the propellant gases which cause the barrel wear. In heavier guns in which the time for the projectile to travel down the barrel is relatively long, for example 7½ cms. guns, the part of the substance beyond the front ⅓ of the charge is fairly effective, especially when using the first substance, and in cartridges for such guns the substance should preferably surround at least the front half, and preferably the front ⅚ of the charge.

Generally speaking the higher the proportion of carbon, the more effective a given layer thickness is. However, some substances react with the propellant gases more rapidly than other substances. Thus, a substance which has a large carbon content and which reacts slowly may have even less effect than a substance which has a lower carbon content but which reacts more rapidly. However, the following empirical formula for determining the minimum layer thickness has proved to be sattisfactory for substances such as those mentioned above:

$$10\sqrt{C}\ \text{mg./cm.}^2$$

where C is the calibre of the firearm in cms.; and cm.$^2$ refers to the area of the layer. The weight of the second substance, such as those mentioned above, which surrounds the front third of the charge should be between 0.05% and 30%, advantageously between 0.5% and 10%, of the weight of the total propellant charge.

The formula given above may be expressed more generally so that it applies to all substances as follows:

$30\sqrt{C}$ gram calories per sq. cm. of layer surface—that is the substance is such that in reacting with the propellant gases it absorbs $30\sqrt{C}$ gram calories per sq. cm. of the layer surface.

The first substance may be dispersed by mechanical mixing throughout the propellant charge. For example, good results have been obtained by dispersing ($AlF_3 3H_2O$) (about 1% of the charge weight) throughout the charge of a 37 mm. gun. However, surprisingly good results have been obtained by dispersing the first substance in fine particles throughout the second substance and applying the mixture in a continuous layer around the charge, either directly on the charge, on fabric covering the charge, or on the inner wall of the case. The primary reason for maintaining the additives and charge separate is that the gas flow in the barrel on combustion of the charge is to a certain extent, laminar. Consequently, if the first substance is uniformly dispersed through the charge a substantial part of the substance in the center of the charge is carried by the propellant gases past the part of the barrel where maximum wear normally occurs. Therefore, to obtain a greater effect, additive materials are advantageously arranged so that they surround the charge. Also, it is better to maintain the additives and charge separate since this enables the additives to be simply and cheaply adapted to existing cartridges so that they incorporate the invention. Still another reason is that the additives may have a slightly deleterious effect on the stability of the propellant.

The preferred form of the invention is illustrated in FIGURE 1 wherein a cartridge is shown having a metal case **20**, propellant charge **24** comprised of propellant strips as is well known, and a projectile **28**. Surrounding charge **24** is a textile wrap **32** which may be of any suitable material such as rayon (preferred) cotton, silk or other conventional materials. The upper section of wrap **32** has a plurality of vertical slits **36** shown therein through part of its length which form flaps **40** as shown in FIGURE 2. Flaps **40** are adapted to be folded in overlapping manner over the upper surface of propellant charge **24**.

Textile **32** is coated, or coated and impregnated with an additive layer **44** composed of powdered tungsten oxide ($WO_3$) dispersed in paraffin wax (melting point approximately 70° C.), preferably 1 part by weight of wax to 2 parts by weight of tungsten oxide. It is preferred that the latter have the texture of talc since smaller particles have generally provided better results for all first substances. In a 75 mm. gun wherein conventional triple base powder composed primarily of nitrocellulose, nitroguanidine and nitroglycerine (calorific value 850) was employed, it was found that optimum results were obtained utilizing additives constituting 3% by weight of the propellant charge.

The additive coating is prepared by melting the wax and thereafter mixing with powdered tungsten oxide. Thereafter, the coating is applied to the fabric in the desired thickness and permitted to cool. The thickness ratio of the top and bottom portions of layer **44** is approximately 3 to 1. The thickness of layer **44** applied to flap sections **40** is substantially the same as the maximum thickness along the sides of the charge.

Coated fabric **32** which is preferably one-half to five-sixths the length of the charge, may be wrapped around the strips of charge **24** or it may be held in position in the cartridge as the propellant material is poured in. Thereafter flaps **40** are folded over and projectile **28** is placed on top of the flaps as shown in FIGURE 1.

As thus applied to the charge the additive coated fabric affords the following advantages:

(1) It positions the thicker portion of layer **40** around the upper part of charge **24** where it will offer optimum performance as previously explained;

(2) It has been found that with coated flaps **40**, better results may be obtained than when no flaps are used. It is believed that this effect results from the flaps opening on combustion of the charge and extending forwardly to liberate the additive material into the forward portion of the case, and in some cases directly into the critical portion of the barrel next to the firing chamber where erosion is normally greatest thereby exposing the latter to additives in a more concentrated form than the additive material along the side of the charge which is delivered to the barrel;

(3) The tapered cross section of layer **44** along the length of charge **24** locates the additive material so that it will be substantially uniformly consumed or liberated from the charge throughout the length of the latter.

If desired, fabric **32** may be secured to the inner wall of the case by glue or other suitable means so as to retain the coated fabric in position.

In FIGURE 4 the arrangement of first and second substances to the charge is the same as that described in connection with FIGURE 1 however, layer **44** is covered with a paper layer **48** or other suitable combustible material for the purpose of further protecting the first and second substances from the effects of heat or vibrations.

In FIGURE 5 is shown a cartridge having a case **52**, charge **56**, and projectile **60**. An additive layer **64** embodying a first and a second substance dispersed therein, is positioned around the charge on the interior surface of casing **52**. Adjacent the interior surface of the additive layer **64** is an optional sheet **68** of suitable combustible material, e.g. paper, celluloid, nitrated cotton, wax paper, thin fabric, etc. Layer **64** extends along a substantial length of the case to a point closely adjacent the lower portion of projectile **60**. The advantage of this is that the additive material will be made immediately available in highly concentrated form to protect the portion of the barrel, usually eroded most severely. Thus, in all embodiments of this invention it will be understood that it is desirable to locate at least a portion of the additive as close to the forward end of the case as is feasible, or alternatively to provide flaps which apparently accomplish this same purpose when the cartridge is discharged. The adhesiveness of the second substance itself will generally be sufficient to hold the additive layer securely in place on the casing wall, particularly where the first substance is dispersed in a layer of carbonaceous carrier material such as cellulose enamel or alkyd resin paint for example.

The material of which layer **68** is composed is selected to afford at least slight cooling effect (in the manner of a second substance) when the round is fired, but more importantly it helps retain additive layer **64** in position and also protects it from deteriorating influences. It will be understood that layer **68** is not essential, but desirable where for example, the cartridges may be stored or used in hot climate or transported over rugged terrain.

It may be desirable to additionally protect and maintain the position of the additive material by enhancing the bond between the casing and additive layer **64**. This may be accomplished by conditioning the case to receive and hold the additive layer more strongly. Thus, in accordance with the embodiment of the invention shown in

FIGURE 5, the area of the inner casing surface to be contacted by layer **64** may be coated with a thin layer of glue or other suitable material to produce a rough surface before additive layer **64** is applied. Or, a thin coarse fabric such as gauze or the like may be applied to the casing inner surface by means of a suitable adhesive for receiving and holding the second substance and dispersed first substance in place.

Alternatively, the first and second substances (tungsten oxide and wax respectively) may be retained on the case wall by being impregnated into layer of porous material having interstitially connected pores such as foam or sponge runbber or foam plastic. Also, since the rubber may serve as a coolant substance the first substance may be applied in a slurry to the porous material and dried.

FIGURE 6 illustrates a cartridge similar to that shown in FIGURE 5 with an additive layer **80** disposed on the inner surface of case **84** around charge **88** but without a thin intermediate textile or paper separating the charge and layer **80**. Also, layer **80** is of uniform thickness throughout its length.

The following examples illustrate different forms of fixed cartridges embodying the invention for use in 37 mm anti-tank gun whose barrel is made of chrome alloy steel and wherein the propellant charge is double base powder containing nitroglycerine and having a calorific value of 1150 calories. The charge weighs 220 grams, and it is arranged in strips each 225 x 12 x 0.65 mm. The cartridge cases are, in all the figures, 250 mm. long.

The cartridge shown in FIGURE 7 comprises a case **100**, a charge **104** consisting of strips tied together by string **106**, and a layer **110** of powdered vanadium pentoxide dispersed in an alkyd resin paint applied to the upper part of the inner wall of the cartridge case. The vanadium pentoxide constitutes 60% by weight of the layer. The thickness of the layer is 0.5 mm.; its length is 50 mm.; and its weight is 3 grams.

The cartridge shown in FIGURE 8 utilizes, for example aluminium fluoride or other first substance contained in a bag **114** located within textile container **118**. The wear reduction obtained with this cartridge is not as great as the wear reduction obtained in the cartridges shown in FIGURE 7, probably because the additive does not surround the charge.

The cartridge shown in FIGURE 9 comprises a case **120**, strips **124** tied together by string **128**, and an additive layer **132**. The first substance, for example pulverulent aluminium fluoride ($AlF_3 3H_2O$) is contained in a plastic ring such as polyethylene for example, located at the upper end of the cartridge case. In this embodiment of the invention the additive layer is relatively thick and short. The increase cross section of the layer enables the gas pressure to readily remove the material from the case into the barrel.

The cartridge of FIGURE 10 is substantially the same as the cartridge of FIGURE 7. The vanadium pentoxide **133** is however not dispersed in an alkyd resin paint but is fixed to the inside of the case by a non-organic or organic adhesive.

The cartridge shown in FIGURE 11 comprises a case **134**, a charge **138** contained in a textile bag, and a coating **42** on the upper part of the charge. The coating extends 10 cms. downwardly from the top of the container and consists of a cellulose enamel containing 70% of vanadium pentoxide. The weight of coating per sq. cm. is 50 mgs.

The cartridge shown in FIGURE 12 comprises a case **146**, a charge **150** and a length of textile **154** wrapped around the upper part of the strips to form a layer containing the two substances. The textile length is coated with an alkyd resin paint **158** containing powdered aluminum fluoride in about 60% of the weight of the dried layer. The coated length **154** extends 10 cms. downwardly from the top of the propellant. The weight per sq. cm. of the layer is 70 mgs.

Tests were carried on with a 20 mm. automatic cannon in which conventional cartridges and cartridges containing different forms of the first substance mechanically mixed with and dispersed throughout the powder were used. The powder used was 7 hole N–C powder, and the total weight of the charge was 37 grams. The initial muzzle velocity was 840 metres/second, and each test consisted of 2 series of firings each of 25 rounds.

The cannon was fitted with a removable sleeve in the area between the chamber and the rifled portion of the barrel. After the firing the sleeve was removed and the wear was ascertained by weighing the sleeve.

| First substance | Weight reduction in mg. | Wear in percent |
|---|---|---|
| None | 131.6 | 100 |
| 1% $AlF_3$ | 95.5 | 72.6 |
| 1% ($AlF_3 3H_2O$) | 14.9 | 11.3 |
| 1% $K_2TiF_6$ | 80.1 | 60.9 |

The first substance may be arranged in the cartridge in ways other than those specifically described; for example it may be contained in a thin sheet (or foil) of propellant containing the first substance; or it may be applied as a layer on celluloid or like foil.

The table below shows various arrangements of the first and second substances for use in a 37 mm. cannon, and the reduction in wear in a removable sleeve achieved in tests similar to those described above:

| First substance | How arranged | Wear in percent (Wear without either substance being regarded as 100%) |
|---|---|---|
| ($AlF_3 3H_2O$) | Contained in a propellant sheet wrapped around the charge. Foil was 0.8 mm. thick and contained 25% by weight of ($AlF_3 3H_2O$). | 20 |
| $CrF_3$ | Contained in a sheet wrapped around charge and composed of propellant. Sheet was 0.8 mm. thick and contained 20% by weight of $CrF_3$. | 20 |
| $MoO_3$ | $MoO_3$ dispersed in varnish ("Ferbolack") applied to a 0.15 mm. thick celluloid foil wrapped around the charge. The length of the layer was 10 cms., and 6 grams of $MoO_3$ was applied to the foil. | 35 |
| $Na_2WO_4$ | $Na_2WO_4$ applied in a layer to 0.15 mm. thick celluloid foil wrapped around charge. The length of the layer was 10 cms. | 65 |
| $CrF_3$ | A cellulose enamel coating applied to the inner surface of the cartridge container and containing 25 gms./cm.$^2$ (approximately 70%) of $CrF_3$. The length of the coating was 5 cms. | 40 |
| $Na_2B_4O_2$ | As a powder dispersed throughout the charge. Powder 2.5% by weight of the charge. | 75 |
| $Cr(NO_3)_3$ | As a powder dispersed throughout the charge. Powder 1.2% by weight of the charge. | 50 |
| $WO_3$ | Contained in a paraffin wax layer on the inside of the cartridge case. The layer was 50 mm. in length and 0.5 mm. in thickness and contained 50% by weight of $WO_3$ although 50–70% has been used successfully. Or instead of $WO_3$, $Nb_2O_5$ was used with equally good results. | less than 5 |
| $Ta_2O_5$ | Contained in a paraffin wax layer on the inside of the cartridge case. The layer was 50 mm. in length and 0.5 mm. thick, and contained 50% by weight of $Ta_2O_5$. | less than 5 |
| $TiO_2$ | Contained in a paraffin wax layer on the inside of the cartridge case. The layer was 50 mm. in length and 0.5 mm. thick, and contained 50% by weight of $TiO_2$. | less than 5 |

The following arrangement of the first and second substance in a cartridge for a 3 inch gun reduced the wear in a steel barrel to 10% of what it was previously—that is a reduction of 90%. A length of fabric coated with paraffin wax having a melting point of 70° C. was wound once around the front ¾ of the tubes of conventional double base nitrocellulose powder containing nitroglycerine housed in a metal case. Powdered tungsten oxide was dispersed in the wax, and constituted 50% by weight of the wax and the weight of the coated textile length was 3% by weight of the charge. Similar tests with nearly equally good results, have been carried out with $TiO_2$ used in place of $WO_3$ in the same amount.

The first substance reduces barrel wear further from the chamber than does the second substance. In addition the coolant second substance may cooperate with the first substance by producing an environment more favorable physical and chemical to the formation of an effective temperature and erosion resistant layer. Thus, a cartridge having both substances results in less barrel wear than a cartridge having only one of the substances.

Although it is preferred to use the first and second substances together in a single layer of additive as described above, it is also possible to effect substantial reductions in barrel wear by using either of the materials individually. In FIGURES 1–12 the second substancee may be used alone arranged in the cartridge in the manner shown and described for the various additive layer positions and arrangements. The relative amount of the second substance as aforesaid, should be between about .05 to 30% of the charge weight for all conventional powders.

Tests using the 37 mm. cartridges, described above, and without the metallic compounds constituting the first substance were carried out. The best results were obtained with a layer of paraffin wax on the inner wall of the case; the layer was 50 mm. long and 0.6 mm. thick; its total weight was 3.5 grams, and the melting point of the wax was 50° C. The wear resulting from this cartridge was 5%—that is a reduction in wear of 95%. With the alkyd resin paint without the vanadium pentoxide particles the wear was 30%, that is a reduction of 70%; with the cellulose enamel coating of FIGURE 11 the wear was 50%; with the alkyd resin coated textile length of FIGURE 12 the wear was 30%.

For ease of application it is preferable to disperse the first substance in the powder charge when used alone, or to place a quantity of the substance on top of the charge strips allowing some to migrate into the space between the strips. The amount of first substance used in its individual application is the same as used in combination with the second substance.

What we claim is:

1. A cartridge having a propellant charge, a single projectile, and an additive for reducing gun barrel wear upon firing of said cartridge, said additive comprising:

(a) a layer of carrier material disposed around said propellant charge and comprised of paraffin having a melting point between 50 and 100° C. and adapted to produce relatively cool gas upon firing of said charge; and

(b) finely divided particles of titanium dioxide contained in said layer of paraffin in an amount sufficient to produce a temperature resistant barrel protector upon firing of said charge.

2. A cartridge having a propellant charge, a single projectile, and an additive for reducing gun barrel wear upon firing of said cartridge, said additive comprising:

(a) a layer of carrier material disposed around said propellant charge and comprised of paraffin having a melting point between 50 and 100° C. and adapted to produce relatively cool gas upon firing of said charge; and

(b) finely divided particles of tungsten trioxide contained in said layer of paraffin in an amount sufficient to produce a temperature resistant barrel protector upon firing of said charge.

3. A cartridge having a propellant charge, a single projectile, and an additive for reducing gun barrel wear upon firing of said cartridge, said additive comprising:

(a) a layer of carrier material disposed around said propellant charge inside an outer surface of said cartridge and comprised of paraffin having a melting point of between 50 and 100° C. and adapted to produce relatively cool gas upon firing of said charge; and

(b) finely divided particles of the oxides of a metal selected from the group consisting of titanium, tungsten, vanadium, tantalum and niobium, said metal being present in an amount sufficient to produce a temperature resistant barrel protector upon firing of said charge.



4. A cartridge having a propellant charge, a single projectile, and an additive for reducing gun barrel wear upon firing of said cartridge, said additive comprising:

(a) a layer of carrier material disposed around said propellant charge and comprised of wax having a melting point of between 50 and 100° C. and adapted to produce relatively cool gas upon firing of said charge; and

(b) a substance in powder form dispersed within said layer, said substance being selected from the group consisting of the oxides of titanium, tungsten, vanadium, tantalum and niobium and said substance being in an amount sufficient to produce a temperature resistant barrel protector upon firing of said charge.

5. A cartridge having a propellant charge, a single projectile, and an additive for reducing gun barrel wear upon firing of said cartridge, said additive comprising,

(a) a layer of carrier material comprised of at least 30% by weight of carbon and adapted to produce relatively cool gas upon firing of said cartridge, and being disposed around said propellant charge,

(b) a substance in powder form dispersed within said layer, said substance being an oxide of a metal selected from the group consisting of titanium, tungsten, vanadium, tantalum and niobium and present in an amount sufficient to produce a temperature resistant barrel protector upon firing of said cartridge.

6. A cartridge as defined in claim 5, wherein said layer of carrier material is coated on textile surrounding said propellant charge.

7. A cartridge as defined in claim 5, wherein said layer of carrier material is tapered in cross section to have a smaller thickness at the rearward portion of the propellant charge.

8. The cartridge as defined in claim 5 further having sheet material coated with said additive and having portions thereof folded over the front end of said propellant charge, whereby said additive is adapted to be readily delivered into said barrel upon firing of said propellant charge.

9. A cartridge as defined in claim 5 further having a flexible sheet material coated with said additive and surrounding said propellant charge, with portions of said sheet cut and folded as flaps over the front end of said propellant charge whereby said additive is adapted to be readily delivered into said barrel upon firing of said charge.

10. A cartridge as defined in claim 9, wherein said flexible sheet is disposed around the forward ½–⅚ of the length of said charge.

11. A cartridge as defined in claim 9, wherein said carrier material on said flexible sheet surrounds at least the front $\frac{1}{20}$ of said charge in a layer sufficiently thick that on combustion it absorbs at least $30\sqrt{C}$ gram calories per sq. cm. of layer surface, where C is the calibre in cm. of the firearm for which the cartridge is intended.

12. A cartridge as defined in claim 9, wherein said layer of carrier material is tapered in cross section to have a smaller thickness at the rearward portion of the propellant charge.

13. A cartridge as defined in claim 9 further comprising a protective, combustible cover on said carrier material.

14. A cartridge as defined in claim 13, wherein said carrier material is wax having a melting point between 50 and 100° C., and said combustible cover is paper.

15. For use in a gun barrel, in combination: a single projectile; a propellant charge for propelling the projectile through the gun barrel; an additive for reducing gun barrel wear resulting from firing of such projectiles, said additive containing as an essential active ingredient a metal compound in powder form which in contact with the hot propellant gases produced by burning of the propellant charge causes no material rise of the temperature at the firing, said metal compound being an oxide of a metal selected from the group consisting of titanium, tungsten, vanadium, tantalum and niobium, said additive being present in a quantity sufficient to provide the inside surface of the gun barrel with a temporary protection having high resistance to temperature and wear.

16. A cartridge as defined in claim 15, wherein said propellant charge is enclosed in a case and said compound is applied to the inner wall of said case.

17. A cartridge as defined in claim 15, wherein said compound is secured to at least the front $\frac{1}{20}$ of the length of said charge.

18. A cartridge as defined in claim 15, wherein said compound is present in an amount ranging from .01 to 20% of the weight of said charge.

19. The combination as defined in claim 15 wherein the metal compound in powder form is titanium dioxide.

20. The combination as defined in claim 15 wherein the metal compound in powder form is tungsten oxide.

21. The combination as defined in claim 15 wherein the metal compound in powder form is vanadium pentoxide.

22. The combination as defined in claim 15 wherein the metal compound in powder form is tantalum oxide fluoride.

23. The combination as defined in claim 15 wherein the metal compound in powder form is niobium oxide.

24. A method of reducing gun barrel wear in a firearm when firing a shot having a single projectile and a propellant charge, comprising introducing into the chamber of the firearm before its discharge an additive containing as an essential element a metal compound in powder form which in contact with the hot propellant gases produced by burning of the propellant charge causes no material rise of the temperature at the discharge, said metal compound being an oxide of a metal selected from the group consisting of titanium, tungsten, vanadium, tantalum, and niobium, the quantity of said additive being sufficient to provide the inside surface of the gun barrel with a layer to compensate for barrel wear due to erosion, and firing said projectile through said gun barrel by igniting said propellant charge to produce said hot propellant gases.

25. The method as defined in claim 24 wherein the metal compound in powder form is titanium dioxide.



26. The method as defined in claim 24 wherein the metal compound in powder form is tungsten oxide.

27. The method as defined in claim 24 wherein the metal compound in powder form is vanadium pentoxide.

28. The method as defined in claim 24 wherein the metal compound in powder form is tantalum oxide.

29. The method as defined in claim 24 wherein the metal compound in powder form is niobium oxide.

30. For use in a gun barrel, in combination: a single projectile; an explosive charge which when fired produces hot propellant gases for propelling the projectile through the gun barrel; an additive for reducing gun barrel wear resulting from firing of such projectiles, said additive being an oxide selected from the group consisting of titanium, tungsten, vanadium, tantalum and niobium and mixtures thereof, and being present in a quantity sufficient to provide on the inside surface of the gun barrel a temporary protection having high resistance to temperature and wear.

31. A method of reducing gun barrel wear in a firearm when firing a shot having a single projectile and a propellant charge, comprising introducing into the chamber of the firearm before its discharge an additive for reducing gun barrel wear, said additive being a finely divided powdery substance having the physical and chemical properties of causing no material rise in temperature of the hot propellant gases at firing and of producing on firing a temperature and erosion resistant layer on the inside surface of the gun barrel by suspending a layer forming substance in the hot rapidly flowing gases emanating from the propellant charge, said additive being an oxide selected from the group of metals consisting of titanium, tungsten, vanadium, tantalum and niobium and mixtures thereof, the amount of the additive introduced being sufficient to provide on the inside surface of the gun barrel a temporary protection having high resistance to temperature and wear, and firing said projectile through said gun barrel by igniting said propellant charge to produce said hot propellant gases.


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# UNITED STATES PATENT OFFICE
# CERTIFICATE OF CORRECTION

Patent No. 3,148,620 September 15, 1964

David E. Jacobson et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 70, for "Vorch" read -- Dorch --; column 4, line 40, for "cartride" read -- cartridge --; column 7, line 13, for "runbber" read -- rubber --; column 8, in the second table, under the heading "How arranged", line 2 thereof, for "Foil" read -- Sheet --; column 9, line 22, for "substancee" read -- substance --.

Signed and sealed this 5th day of January 1965.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents

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