July 16, 1968 J. P. PICARD 3,392,670

EROSION REDUCER

Original Filed Jan. 24, 1966

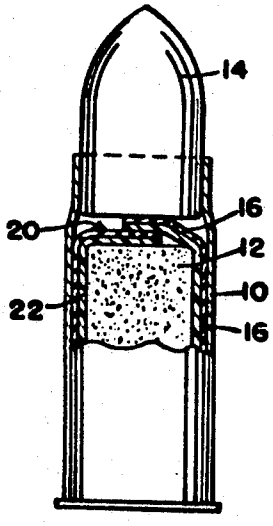


FIG. 1.

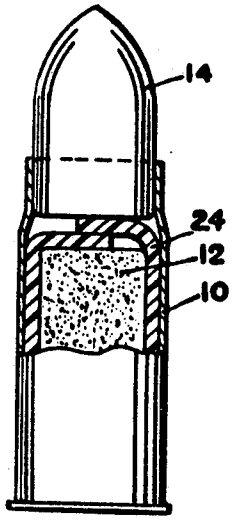


FIG. 3.

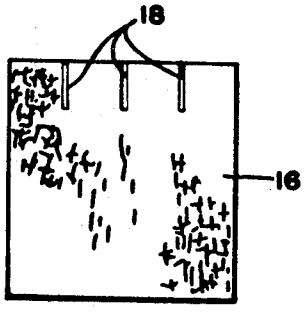


FIG. 2.

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EROSION REDUCER

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Continuation of application Ser. No. 522,796, Jan. 24, 1966. This application Oct. 17, 1967, Ser. No. 676,681
24 Claims. (Cl. 102—38)

ABSTRACT OF THE DISCLOSURE

Inorganic additives such as SiO_2 or MgO, individually, or in any proportion, or as SiO_2 and MgO occur in nature as talc, when added to propellant systems such as ordnance weapons, will reduce wear or erosion in metallic members coming in contact with hot gases formed upon ignition of the propellant.

This application is a streamline continuation of application Ser. No. 522,796, now abandoned.

The invention described herein may be manufactured and used by or for the Government for governmental purposes without payment to me of any royalty thereon.

This invention relates broadly to ordnance items and more particularly concerns inexpensive and readily available chemical additives which are used with propellant systems for reducing wear or erosion in members, such as gun barrels, coming in contact with hot gases formed by ignition of the propellant.

The problem of excessive gun barrel wear has been a most vexing one because of economy and technical considerations. Jacobson et al., U.S. Patent No. 3,148,-620, deals with the problem at length. However, the problem has not been adequately solved principally due to needed further gun barrel wear resistance and the generally high cost of additives employed. Etzkorn, German patent, 719,418, discusses the application of lubricating mechanisms to improve gun barrel wear by reducing friction when a bullet moves through a barrel. His device requires the use of cartridge bags having fibers of about 1 to 6 denier, the bag containing the lubricating medium or the lubricant is embodied in the fibers of the bag. Quite obviously, his lubricating device does not lend itself to modern production methods and is altogether too costly when considering the tremendous quantities of cartridges manufactured by or for the Government today.

It is therefore a broad object of this invention to economically reduce the wear or erosion in a member, such as weapon barrel, which is subjected to hot gases formed by ignition of propellant.

Another object of the invention is to provide cartridges with economically and readily available chemical additives which produce a laminar cooling layer on surfaces of members to be protected against wear, said additives being most efficient in reducing gun barrel wear, and smoke and flash upon ignition of propellant within the cartridge.

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 exemplary embodiments and wherein:

FIG. 1 is a front elevation view, partly broken away,

of a cartridge embodying an additive of the present invention;

FIG. 2 is a view of an unfolded sheet utilized in the cartridge of FIG. 1; and

FIG. 3 is a modified cartridge of FIG. 1.

FIGURE 4 is a further modification of a cartridge embodying the additives of the present invention wherein such additives are in an encapsulated form.

Briefly, the present invention is based on my discovery that by incorporating certain inorganic additives (with cellulosic fibers if additional strength is desired) into a propellant container, such as a cartridge case, for example, that gun barrel erosion can be greatly reduced.

More specifically, I have discovered that inexpensive and readily available additives, such as SiO_2 or MgO, individually, or mixed in any proportion, or as MgO and SiO_2 occur in nature as talc, having the empirical formula $3MgO.4SiO_2.H_2O$, if contained within a cartridge case or propellant container, when incorporated within suitable textile or plastic compositions and placed inside the cartridge case or propellant container, that gun barrel erosion is remarkably reduced as well as smoke and flash when the cartridge is fired. If a mixture of the oxides is used, I have found that excellent results are obtained when the oxides have the following ranges:

	Wt. percent
SiO_2	45–65
MgO	20–55

The oxides are preferably of fine particle size ranging between about 3 to 60 microns and it is not necessary that the oxides be free from ordinary impurities carried therewith. If the natural occuring mineral, talc, is used, it may constitute the entire additive.

The oxides, individually or mixed, or talc, will be used in quantities varying between about 1 to 5 weight percent of the propellant charge, depending upon the operating pressure of the weapon involved and the type propellant being employed. The cellulose fibers, when used, will constitute about 1 to 2% of the weight of the SiO_2, or MgO, or a mixture thereof, or talc.

My additives may be dispersed in a carbonaceous carrier material such as paraffin or microcrystalline waxes and other hydrocarbons melting between about 70 to 400° F., or the additives may be incorporated within a suitable matrix such as plastic foam synthetic fibers, and the like. Very satisfactory results have been obtained with polyurethane foams and paraffin waxes, the latter having a preferred melting point between about 120 to 250° F. Optionally, the additives of the invention may be used advantageously without any carrier material as will be described in detail hereinafter.

When a carrier is employed, my inventive sheet will comprise the chemical additive or additives dispersed in a carrier wax which will be impregnated in a textile adjacent the front part of the charge. Determination of minimum sheet thickness can be readily computed from the formula set forth in the patent to Jacobson et al. supra:

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

Where C is the calibre of the firearm or weapon in cms.; and cm.^{2} refers to the area of the sheet. By sheet, I refer to my additives, incorporated or dispersed, whether generally homogeneously or not within a wax carrier, including the textile or fabric upon which it is coated or impregnated. When polyurethane foams are employed

as the "textile," my additive will be incorporated therewithin to comprise the sheet.

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 sheet 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 sheet surface.

One embodiment of my invention is illustrated in FIG. 1 wherein a cartridge is shown having a metal case **10**, propellant charge **12** comprised of a suitable propellant to be hereinafter described and a projectile **14**. Within case **10** and in contact with the inner surface thereof is a textile wrap **16** which may be of any suitable material such as rayon (preferred), cotton, silk, and the like. The upper section of wrap **16** has a plurality of vertical slits **18** (FIG. 2) through part of its length which form flaps **20** as shown in FIG. 1.

Textile **16** is coated, or coated and impregnated with an additive layer **22** composed of powdered SiO_2, powdered MgO, or a powdered mixture of both, or talc. Flaps **20** and the additive layer coating **22** are adapted to be folded in overlapping manner over the upper surface of propellant charge **12**.

The additive coating is prepared by melting the wax and thereafter mixing with my powdered additive in proportions hereinafter described. Thereafter, the coating is applied to the fabric in the desired thickness and permitted to cool and thus forming my sheet.

When a cartridge is prepared without a carrier material in accordance with my invention, the SiO_2, or MgO, individually, or in combination, or talc, may be admixed or incorporated directly within propellant **12** or coated directly onto the outer surfaces thereof, the chemical additives in either case comprising about 1 to 5 percent by weight of the propellant charge.

Optionally, my additives may be enclosed or contained in small plastic capsules, of cellulose acetate, for example, and dispersed throughout the propellant or the additives may be simply dropped into a cartridge case or propellant container prior to its loading, the additives again comprising about 1 to 5 percent by weight of the propellant charge. Obviously, if no carrier is used, the necessity of employing a fabric or plastic foam is completely obviated.

Coated fabric **16** which is preferably one-half to five-sixths the length of the charge, may be wrapped around the propellant **12** or it may be held in position in the cartridge as the propellant material is poured in. If desired, fabric **16** may be secured to the inner wall of the case by glue or other suitable means so as to retain the coated fabric in positions. Thereafter flaps **20** are folded over and projectile **14** is placed on top of the flaps as shown in FIG. 1. It will be understood that the invention is equally applicable to cartridges other than as illustrated. For example, artillery ammunition of the fixed, semifixed, separated or separate-loading types may be used advantageously with the additives described.

In the modified cartridge of FIG. 3, a sponge-like polyurethane foam **24**, impregnated with the additives of my invention, replaces the textile **16** and layer **22** of the cartridge of FIG. 1 and will similarly be provided with slits at its upper portion to facilitate its folding in an overlapping manner over the upper surface of propellant charge **12**. If desired, the impregnated polyurethane foam material may be glued, for example, to the inner wall of the case in a manner similar to the textile sheet.

In preliminary testing of the effectiveness of my inexpensive and readily available additives, laboratory apparatus was used which comprised a modified closed bomb simulating gun firing. The effectiveness of my additives was evaluated by measuring loss in weight of perforated steel cylinders employed to vent the combustion products produced by the burning propellant and around a selected

portion of which was placed my sheet or impregnated polyurethane foam, or my additives were admixed into the propellant directly as aforedescribed. My additives work with equal effectiveness in cartridges and shells ranging from 22 calibre small arms ammunition to 205 mm. ammunition. The amount and thickness of my additive sheet or impregnated polyurethane foam when a carrier is used, will depend on the size of the cartridge or shell as aforedescribed. For example, the textile **16** for a 105 mm. high explosive antitank shell was a piece of rayon woven from spun viscose rayon yarn containing a durable water repellant of melamine resin base and weighed between 2.80 and 3.20 ounces per square yard. The rayon was placed on a smooth surface and my additives poured thereon and spread evenly by scraping with a blade and resulted in a sheet slightly under $\frac{1}{16}$ in thickness. Determination of minimum sheet thickness can be readily computed for any calibre weapon from the formula aforementioned. In the case of impregnated polyurethane foams, the identical formula for calculating sheet thickness will be used.

The propellants used in determining the effectiveness of my additive are described in Table I below:

TABLE I.—PROPELLANT COMPOSITIONS AND PROPERTIES THEREOF

Propellant	M2	M9	M30
Composition:			
Nitrocellulose	77.45	57.75	28.00
(Percent N in nitrocellulose)	(13.25)	(13.25)	(12.6)
Nitroglycerin	19.50	40.00	22.50
Nitroguanidine			47.70
Potassium Nitrate		1.50	
Barium Nitrate			
Ethyl Centralite	0.60	0.75	1.50
Cryolite			0.30
Graphite	0.30		
Graphite (Glaze)			0.10
Ethyl Alcohol (Residual)	2.30	0.50	0.30
Water (Residual)	0.70	0.00	0.00
Thermochemical Properties:			
Isochoric Flame Temp., ° K	3319	3799	3040
Force, ft.-lbs./lb	360,000	382,000	364,000
Unoxidized Carbon, percent	Zero	Zero	3.2
Combustibles (H_2+CO), percent	47.2	32.8	41.0
Heat of Explosion, cal./gm	1080	1295	974
Gas Volume, moles/gm	0.03900	0.03618	0.04308

To show the superiority of my additives over other known additives, an erosion study was conducted using M2 propellant wherein the fabric material was a spun viscose rayon yarn as aforedescribed and the polyurethane foam had a density of 22 pounds per cubic foot although foams ranging between about 10 to 30 pounds per cubic foot have been found to work very satisfactorily.

TABLE II.—EROSION STUDY

Propellant:
- Type ---------- M2.
- Charge ---------- 35 grams.
- Pressure range ---------- 15,000 p.s.i. to 16,000 p.s.i.

Additive	Weight of Additive, grams	Erosion per shot expressed in mg. loss in weight per shot
Propellant (alone)		24.1
Paraffin wax (M.P. 140° F.)	2.2	2.8
Paraffin wax (M.P. 180° F.)	4.0	2.7
TiO_2 (alone)	2.0	19.0
$CaSO_4$ (alone)	2.0	27.0
$CuSO_4$ (alone)	2.0	24.0
Talc (alone)	2.0	1.0
45 pts. $CuSO_4$/55 pts. wax	4.0	6.5
45 pts. $CaSO_4$/55 pts. wax	4.0	6.8
45 pts. TiO_2/55 pts. wax	4.0	0.8
45 pts. SnO_2/55 pts. wax	4.0	7.4
45 pts. ZrO/55 pts. wax	4.0	5.3
45 pts. SiO_2/55 pts. wax	4.0	0.2
45 pts. 65/35 SiO_2/MgO/55 pts. wax	4.0	0.2
45 pts. California talc/55 pts. wax	4.0	0.2
45 pts. New York talc/55 pts. wax	4.0	0.2
45 pts. Montana talc/55 pts. wax	4.0	0.2
22 pts. 65/35 SiO_2/MgO/78 pts. polyurethane foam	4.0	0.7

In all cases, the oxides or talcs used were of a particle size of about 20 microns and the wax had a melting point of about 1780° F., unless otherwise indicated.

The chemical compositions of the aforementioned talcs are presented in Table III below.

TABLE III.—CHEMICAL COMPOSITION OF TALCS USED

	Theoretical	California	New York	Montana
Ingredients, percent:				
H_2O (chemically bond)	4.80	3.83	3.00	4.76
SiO_2	63.50	59.15	54.40	62.51
MgO	31.70	27.96	29.85	30.59
Al_2O_3		0.36	0.60	0.18
Fe_2O_3		0.26	0.18	0.99
MnO		0.004	0.10	Trace
TiO_2		0.007	None	None
CaO		5.17	7.10	0.22
Na_2O		1.16	0.30	0.09
K_2O		0.49	0.13	0.03
CO_2		2.29	.338	0.44
SO_4		None	None	None
H_2O (loss at 105° C.)		0.28	0.56	0.26
Particle size in micron		3–60	3–60	3–60

When M9 propellant was used, the following results were obtained:

TABLE IV.—EROSION STUDY

Propellant:
Type ..... M9, Flake (3 mils).
Charge ..... 42 grams.
Pressure Range ..... 50,000 p.s.i. to 55,000 p.s.i.

Additive	Weight of additive grams	Erosion per shot expressed in mg. loss in weight per shot
Propellant (alone)		150.0
60/40 SiO_2/MgO (alone)	2.25	56.0
50/50 SiO_2/MgO (alone)	2.25	60.0
SiO_2 (alone)	2.25	49.1
Wax, (M.P. 140° F.)	2.25	2.8
Wax, (M.P. 160° F.)	2.25	3.6
Wax, (M.P. 180° F.)	2.25	2.1
Wax, (M.P. 140° F.)	4.50	2.7
Wax, (M.P. 160° F.)	4.50	3.4
Wax, (M.P. 180° F.)	4.50	2.0
45 pts. TiO_2/55 pts. wax (M.P. 200° F.)	4.50	14.8
45 pts. 65/35 SiO_2/MgO/55 pts. wax (M.P. 200° F.)	4.50	2.2
20 pts SiO_2/80 pts. wax (M.P. 200° F.)	4.50	1.3
20 pts. MgO/80 pts. wax (M.P. 200° F.)	4.50	1.3
45 pts. 60/40 SiO_2/MgO/55 pts. wax (M.P. 200° F.)	4.50	1.2
22 pts. 65/35 SiO_2/MgO/78 pts. wax (M.P. 200° F.)	4.50	1.0
45 pts. California talc/55 pts. wax (M.P. 200° F.)	4.50	1.2
22 pts. Montana talc/78 pts. wax (M.P. 200° F.)	4.50	1.0
22 pts. New York talc/78 pts. polyurethane (density of 22 lbs./ft.^{3})	4.50	1.8
22 pts. 50/50 SiO_2/MgO/78 pts. polyurethane foam (Density 22 pounds/ft.^{3})	4.50	1.8

In all cases above, the oxides or talcs were of the order of 20 micron particle size.

Preparation of the project of this invention will be more clearly understood from a consideration of the following specific examples which are given for the purpose of illustration and are not intended to limit the scope of this invention in any way.

Example I

47 grams of New York talc having a particle size ranging between 3 to 60 microns are stirred into 53 grams of melted paraffin wax having a melting point of 180° F. The resultant mixture was thoroughly mixed while maintaining the temperature at about 100° C. and then poured onto a piece of spun viscose rayon yarn of melamine resin base, the rayon yarn having been placed on a smooth surface. By means of a scraping blade, a uniform thickness of about 1/16 inch of additive wax was obtained. If desired, the melted additive wax mixture can readily be poured in molds of varying configurations.

Example II

22 parts of Montana talc having a particle size ranging between about 5–40 microns are stirred into 82 parts of a resin prepolymer consisting of:

	Parts
Polyethylene glycol, low molecular wt.	10.5
Polyethylene glycol, high mol. wt.	6.5
Castor oil	36.48
Tolyl di-isocyanate	46.47
Acetyl chloride	0.05

After thorough mixing of the additive and prepolymer, 9.5 parts of a catalyst consisting of:

	Parts
Polyethylene glycol, low vol. wt.	17.2
Glycerol (2.5% H_2O)	34.5

and 8.5 parts of another catalyst consisting of:

	Parts
Polypropylene glycol nioxdiol	46.2
Dibutyl tin di-2-ethyl Hexoate	1.0

are added thereinto and further thoroughly mixed, and then poured into a container, suitably of steel or aluminum, for example, and cured at 210° F. for at least 2 hours. The resultant mass or "bun" of impregnated polyurethane foam is then permitted to cool, removed from the container or mold and sliced into sheets of desired thickness with a band saw for use in cartridge case or, as described under Example I, may be poured into molds while yet in a pourable condition.

Example III

17 pounds of California talc having an average particle size of 30 microns was mixed with 0.2 pound of cellulose fiber, 6 to 9 grams denier and about ½ inch long, and then thoroughly stirred into 22 pounds of molten paraffin wax having a melting point of 180° F. The resultant mixture was poured onto a spun viscose rayon cloth of melamine resin base as aforementioned to produce a uniform layer approximately 1/16 inch thick. When inserted in a 105 mm. cartridge in accordance with the invention, the cartridge being loaded with M30 propellant, the erosion on the gun barrel after firing 100 rounds therethrough was 0.002" on the barrel lands and 0.000" on the barrel grooves. When the same test was performed using identical amounts of TiO_2 or $CaSO_4$ and wax having identical particle sizes and melting points, the barrel lands were eroded 0.006" and 0.01" respectively and the barrel grooves 0.000" in both cases. Additionally, the TiO_2-wax additive produced substantially more smoke and flash than my talc-wax additive aforedescribed.

The cost of my additives, i.e., SiO_2, MgO or talc does not exceed about 5 cents a pound and is considerably more inexpensive than other prior art additives.

Although my impregnated polyurethane foam materials are not as effective as the talc-wax, MgO-wax, SiO_2/MgO-wax sheets, it is believed that the results obtained still indicate its high degree of satisfactoriness in reducing gun barrel erosion.

It is apparent from the foregoing description that I have provided additives for use in propellant systems wherein members coming in contact with hot gases produced by ignition of the propellant are protected against wear and erosion by the formation of cooler layers of gas adjacent the member. Plastic and fiberglass members as well as fiberglass-metal members also benefit from the additives of the invention. My additives are characterized by inexpensiveness and their high adsorptivity for hydrocarbons and certain organic compounds which lends itself admirably for admixing into waxes and polyurethanes. Further, the ballistic performance of weapons employing my cartridge additives are not at all adversely affected.

Reference is hereby made to patent application Ser. No. 523,015, of Daniel Katz, for "Wear Reduction Additives," filed Jan. 24, 1966, now Patent No. 3,362,328, assigned to the same assignee of this patent application.

I claim:

1. In a propellant system for providing thrust whereby hot gases are produced upon ignition of propellant and including means for containing said propellant, the combination therewith of the improvement for reducing erosion of members coming in contact with said hot gases, said improvement comprising an additive of

$3MgO \cdot 4SiO_2 \cdot H_2O$

incorporated within said containing means, said additive comprising 1 to 5 weight percent of the weight of said propellant.

2. The system of claim 1 further characterized by said additive being admixed with said propellant.

3. The system of claim 1 further characterized by said additive being coated on exterior surfaces of said propellant.

4. The system of claim 1 further characterized by said additive being encapsulated in plastic and dispersed throughout said propellant.

5. The system of claim 1 further characterized by said additive being disposed adjacent a base end portion of said containing means.

6. In a system having a projectile associated with a cartridge having a propellant and means for containing said propellant, the combination therewith of the improvement for reducing erosion of members coming in contact with hot gases produced upon ignition of said propellant, said improvement comprising an additive within said containing means of

$$3MgO \cdot 4SiO_2 \cdot H_2O$$

7. A cartridge as described in claim 6 wherein said additive comprises about 1 to 5 weight percent of the propellant, said additive being admixed with said propellant.

8. A cartridge as described in claim 6 wherein said additive comprises about 1 to 5 weight percent of the propellant, said additive being coated on exterior surfaces of said propellant.

9. A cartridge as described in claim 6 wherein said additive comprises about 1 to 5 weight percent of the propellant, said additive being encapsulated in plastic and dispersed throughout said propellant.

10. A cartridge as described in claim 6 wherein said additive comprises about 1 to 5 weight percent of the propellant, said additive being disposed on a bottom portion of said cartridge case.

11. In a system having a projectile associated with a cartridge having a propellant charge and means for containing said propellant charge, the combination therewith of the improvement for reducing erosion of members coming in contact with hot gases produced upon ignition of said propellant charge, said improvement comprising a sheet surrounding at least an upper half of said propellant, said sheet comprising a pervious material impregnated with a chemical additive of

$$3MgO \cdot 4SiO_2 \cdot H_2O$$

12. In a system having a projectile associated with a cartridge having a propellant charge and means for containing said propellant charge, the combination therewith of the improvement for reducing erosion of members coming in contact with hot gases produced upon ignition of said propellant charge, said improvement comprising a sheet of a pervious textile fabric impregnated with a dispersion of a carrier and

$$3MgO \cdot 4SiO_2 \cdot H_2O$$

13. The cartridge of claim 12 wherein said carrier is hydrocarbon.

14. The cartridge of claim 15 wherein said hydrocarbon is characterized by a melting point between about 70–400° F.

15. The cartridge of claim 12 wherein said carrier is paraffin wax.

16. The cartridge of claim 12 wherein cellulose fibers are incorporated within said dispersion.

17. The cartridge of claim 16 further characterized by said cellulose fibers constituting between about 1 to 2 weight percent of said material.

18. The cartridge of claim 16 further characterized by said cellulose fibers being about 6 to 9 grams denier and about ½ inch long.

19. The cartridge of claim 14 further characterized by said material having a particle size range of about 3 to 60 microns.

20. In a propellant system for providing thrust whereby hot gases are produced upon ignition of propellant and including means for containing said propellant, the combination therewith of the improvement for reducing erosion of members coming in contact with said hot gases, said improvement comprising an additive selected from the group consisting of MgO, SiO_2, a combination of MgO and SiO_2, and talc, incorporated within said containing means, said additive comprising 1 to 5 weight percent of the weight of said propellant, said additive being encapsulated in plastic and dispersed throughout said propellant.

21. In a system having a projectile associated with a cartridge having a propellant and means for containing said propellant, the combination therewith of the improvement for reducing erosion of members coming in contact with hot gases produced upon ignition of said propellant, said improvement comprising an additive within said containing means selected from the group consisting of MgO, SiO_2 , a combination of MgO and SiO_2, and talc, said additive comprising about 1 to 5 weight percent of the propellant, said additive being encapsulated in plastic and dispersed throughout said propellant.

22. In a system having a projectile associated with a cartridge having a propellant charge and means for containing said propellant charge, the combination therewith of the improvement for reducing erosion of members coming in contact with hot gases produced upon ignition of said propellant charge, said improvement comprising a sheet of a pervious textile fabric impregnated with a dispersion of a carrier and a material selected from the group consisting of SiO_2, a mixture of SiO_2 and MgO, and talc, and wherein cellulose fibers are incorporated within said dispersion.

23. In a system having a projectile associated with a cartridge having a propellant charge and means for containing said propellant charge, the combination therewith of the improvement for reducing erosion of members coming in contact with hot gases produced upon ignition of said propellant charge, said improvement comprising a sheet of a pervious textile fabric impregnated with a dispersion of a carrier and a material selected from the group consisting of SiO_2, MgO, a mixture of SiO_2 and MgO, and talc, wherein cellulose fibers are incorporated within said dispersion, and said cellulose fibers constitute between about 1 to 2 weight percent of said material.

24. In a system having a projectile associated with a cartridge having a propellant charge and means for containing said propellant charge, the combination therewith of the improvement for reducing erosion of members coming in contact with hot gases produced upon ignition of said propellant charge, said improvement comprising a sheet of a pervious textile fabric impregnated with a dispersion of a carrier and a material selected from the group consisting of SiO_2, MgO, a mixture of SiO_2 and MgO, and talc, wherein cellulose fibers are incorporated within said dispersion, and said cellulose fibers are about 6 to 9 grams denier and about ½ inch long.

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ROBERT F. STAHL, *Primary Examiner.*