United States Patent Office 3,112,553 Patented Dec. 3, 1963

3,112,553

ELECTROFORMING OF GUN LINERS

William H. Safranek, Columbus, Ohio, assignor to the United States of America as represented by the Secretary of the Army

No Drawing. Filed June 8, 1960, Ser. No. 34,849
1 Claim. (Cl. 29—1.1)

This invention relates to electroformed gun barrel inserts or liners of a chrome-iron alloy which is too hard for fabrication.

A gun barrel is subjected to unusual conditions which affect the maintenance of the bore, such as corrosion and erosion and which eventually affect the accuracy of the weapon. The ordinary primer compositions contain potassium chlorate as an oxygen carrier. On explosion of the primer, however, the chlorate decomposes, giving off oxygen, while a chloride remains as a finely divided solid, which not only attacks the metal of the bore, but enters pits in the bore surfaces, thereby causing corrosion or rusting of the steel of which the barrel is made. Even when the bore is cleaned immediately after firing, traces of the chloride still remain, especially in the pits so that corrosion is not prevented. Furthermore, the powders employed have a corrosive action on the bore, and this is even true of smokeless powders having a nitro-cellulose base, for oxides of nitrogen are generated by the burning of the powder, and these oxides are very active chemically to dissolve and attack the steel, thereby causing pitting and corrosion. Even atmospheric conditions affect the bore walls, for the moisture in the air permits oxidation to take place so that the steel barrel accumulates rust, thereby causing pitting. After a certain number of rounds of ammunition are fired in a gun, the gun becomes so worn by erosion that it will not have the required diameter, and this is particularly true in rifles; accordingly the accuracy is finally so affected that the barrel must be replaced, for it cannot be rebored and still maintain the diameter required for the ammunition for which it is designed. Furthermore, most high velocity rifle bullets used at the present are jacketed with some alloy which will keep the lead from melting and will engage the rifling properly. Most of these jacket materials possess such an affinity for steel, of which rifle barrels are usually made, as to alloy therewith under the influence of high temperature, velocity and pressure, thus producing the phenomenon known as "metal fouling" which means a slow accretion inside the barrel of substances taken from the bullets, which always interferes seriously with the accuracy of the weapon and may lead to the bursting of the gun barrel.

One of the objects of this invention is, therefore, to provide a gun barrel whose bore is so formed that corrosion, pitting and erosion are reduced to a minimum.

This object is attained by providing a liner for a gun barrel whose bore is plated, preferably with a plating which is extremely hard, retains its hardness at firing temperatures, and is, therefore, practically noncorrosive. Such a plating may be made of a chromium iron alloy, containing at least 85% chromium and the balance iron.

Since such an alloy is too hard to be machined, another object of this invention is to provide a practical process for forming a gun liner of this alloy.

Such a liner may be formed by electroplating a metallic mandrel, whose external diameter is the same as the desired calibre of the liner, with a chromium iron alloy containing at least 85% chromium with the balance iron. The coated mandrel is then electroplated in another bath with a metal or alloy having greater ductility than the chromium iron coat, such as nickel or an alloy of nickel and iron. The mandrel around which the liner of this invention is electroplated is usually of copper

or a low melting point metal such as lead, in the former case the mandrel would be removed by machining while in the latter the mandrel would be melted and run out of the liner. The liner as formed is inserted in the gun barrel and heated to aproximately 400° C.; such a heat treatment will bond the liner to the gun barrel by means of the nickel or nickel-iron alloy coating which will become sufficiently ductile for the purpose.

The process for forming the gun liners may be specifically carried out as follows: the copper mandrel whose external diameter is the same as the desired bore of the liner is hand polished and then electropolished at 450 amps./sq. ft. for about 125 minutes at 60° C. in an electropolishing bath consisting of 76% by weight of orthophosphoric acid and containing 1% of aluminum, the specific gravity of the bath being 1.65 to 1.67 at 52° C.; the polished mandrel is then electroplated with an alloy of 6% iron and the balance chromium from a second bath having the following composition,

	G./l.
Chromium ammonium sulphate $[Cr(NH_4)(SO_4)_2.12H_2O]$	300
Ammonium sulphate $(NH_4)_2SO_4$	100
Ferrous ammonium sulphate $Fe(NH_4)_2(SO_4)_2.6H_2O$	4.2

pH 1.85 to 1.9 and the addition of 15–20 ml./l. of 29% aqueous ammonia are required to establish the desired pH. The above bath was made up by heating 8 liters of distilled water to boiling, adding 4536 grams of chromium ammonium sulphate, 1510.5 grams of ammonium sulphate, and 70 grams of ferrous ammonium sulphate with continuous stirring. The pH was adjusted with 29% aqueous ammonia and 150 ml. were required. 150 gm. of activated carbon wetted with 500 ml. of distilled water were stirred into the plating solution and the stirring continued for one hour at 71° C. The solution was filtered, using purified wood cellulose as a filter agent, and the filtrate was diluted with distilled water to bring the volume up to 15 liters. Using this solution as the bath the mandrel was electroplated for 70 hours at 100 amps./sq. ft. cathode current density at 46° C., the anode current density being approximately 50 amps./sq. ft. The iron and chromium content of the bath was maintained by dissolution of a soluble alloy anode containing 6% iron and the balance chromium. Formation of ferric iron at the surface of the alloy anodes was reduced by supplying divalent chromium from an auxiliary tank, while the overflow from the main tank was returned to the auxiliary tank. The mandrel was rotated at 60 r.p.m. to make a uniform deposit, and was oscillated at 32 c.p.m. with a one inch stroke to provide agitation while pH was maintained in the range 2.0 to 2.1 by the addition of sulphuric acid.

The chromium-iron plated mandrel was washed in cold water and then electroplated with nickel in a bath containing the following compounds:

Nickel sulphate ($NiSo_4.6H_2O$)	g./l.	330
Nickel chloride ($NiCl_2.6H_2O$)	g./l.	38
Boric acid (H_3BO_3)	g./l.	38
Wetting agent, XXXD	percent by volume	.75

The anode and cathode current densities were both 35 amps./sq. ft., the temperature 63° C. and the pH was maintained in the range of 3.3 to 4.0 by the addition of sulphuric acid as required. The solution was filtered continuously at two liters per minute. The mandrel was rotated at 60 r.p.m. and oscillated at 32 c.p.m. with a one inch stroke. Electrodeposition was continued for five days and a wall thickness of one-quarter of an inch was deposited.

The center of the copper mandrel was bored out with a 9/16 inch drill and the remainder of the copper was dissolved with nitric acid solution (sp. gr. 1.42) at 35° C.

While copper is the preferred material for the mandrel, other metals or alloys with a low melting point, for example, such as lead may be used for the mandrel, thus permitting the mandrel to be removed by melting.

The nickel coated liner is then inserted in the gun barrel and heat treated to about 400° C. whereby the nickel coating becomes ductile and on cooling bonds the liner to the gun barrel. If the mandrel had been made of lead or a low melting point alloy, the mandrel would be removed during this heat treatment by melting and draining off.

The cathode current density should be held down to approximately 100 amps./sq. ft., as it has been found that chromium-iron liners formed at higher cathode current densities, for example amps./sq. ft. prone to crack when sawed or heat-treated.

Variations may be made in the concentration of the agents in the bath. For example, chromium (as Cr) may range from about 30–40 g./l. and iron from about 6–8 g./l. The pH may be varied from about 1.4 to 2.5, preferably from 1.8 to 2.1. Chromium-iron deposits of varying compositions, ranging from 5–15 percent iron and the balance chromium, have satisfactory hardness and erosion characteristics and can be deposited according to this invention.

It will therefore be seen that the invention accomplishes its objects. By coating or plating the inside of the gun barrel with an alloy as described, not only is abrasion and erosion greatly retarded, but corrosion is practically eliminated. Not only is the plating substantially non-corrosive under the action of a propellant charge when fired in the barrel and substantially non-erosive under the action of a projectile fired through the bore and in contact with the plating; but the plating being smooth as well as hard and maintained in a polished condition, the friction between the projectile and the bore is reduced and maintained at a minimum. Corrosion, as well as fouling, due to adhesion of the projectile to the bore walls in passing therethrough is obviated; this is not only true where soft projectiles of lead are used, but also where jacketed or plated bullets are employed. Accordingly,

not only is the life of the barrel increased, but its initial accuracy will be maintained for a longer period. Moreover, the barrel, after having its bore worn, need not be discarded, may be fitted with a new liner or the old liner may be replated. Replacement of a worn liner may be easily accomplished by heating the gun barrel sufficiently to melt the nickel binder which permits the removal of the liner from the gun barrel.

It is obvious that various changes may be made in the details of this process, within the scope of the appended claim, without departing from the spirit of this invention.

Having thus described the invention, what is claimed is:

The method of making liners for gun barrels comprising, electroplating on a mandrel made of a metal with a low melting point a coat of a chrome-iron alloy for a liner containing at least 85% chromium the balance iron, electroplating the coated mandrel with a ductile coat of nickel in another bath, inserting the twice-coated mandrel within a gun barrel and heating the outside of the gun barrel to a temperature of approximately 400° C. for the purpose of making the surface of the nickel coating sufficiently ductile to bond the liner to the barrel and in the same operation remove the mandrel by melting, said liner being removable on the melting of the nickel bond.

References Cited in the file of this patent

UNITED STATES PATENTS

930,927	Berkstresser	Aug. 10, 1909
1,513,119	Madsen	Oct. 28, 1924
1,886,218	Olin et al.	Nov. 1, 1932
2,636,849	Brenner	Apr. 28, 1953
2,822,326	Safranek	Feb. 4, 1958
2,990,343	Safranek	June 27, 1961

OTHER REFERENCES

Metals Handbook, 1948 edition, published by the American Society for Metals, Cleveland (pages 718 and 1026 of interest).