(11) International Publication Number: WO 98/02706
(43) International Publication Date: 22 January 1998 (22.01.98)

(21) International Application Number: PCT/US97/12182
(22) International Filing Date: 15 July 1997 (15.07.97)

(30) Priority Data:
08/680,490 15 July 1996 (15.07.96) US
08/713,676 17 September 1996 (17.09.96) US


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(81) Designated States: AU, CA, CN, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: ELECTRICALLY INSULATED FIRING PIN

(57) Abstract
Electrically insulated firing pin (1) for use in a firearm for firing electrically activated ammunition.
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ELECTRICALLY INSULATED FIRING PIN

CROSS-REFERENCE TO RELATED APPLICATION

This is a Continuation-in-part of copending applications Serial Number 08/680,490 filed July 15, 1996, and Serial Number 08/713,676 filed September 17, 1996.

BACKGROUND OF THE INVENTION

This invention relates to firearms and more particularly to those firearms adapted to fire electrically activated ammunition. Specifically, the present invention relates to a firing pin, for use in such a firearm, having an electrical insulating surface.

Prior references to electronic firearms disclose means, separate from the firing pin, of electrically insulating the firing pin from conductive surfaces or objects within the firearm. Sleeves adapted to surround and insulate the firing pin have been disclosed, however, these and other prior methods of electrically insulating the firing pin have proven to be less durable than desired. Coatings and sleeves made from plastics or ceramics are known means of insulating in the electronic arts, however, these are adversely affected by repeated exposure to the gases, chemicals, and forces resulting from the ignition of a round of ammunition in the chamber of a firearm adjacent to the firing pin and bolt assembly. Accordingly, there is an unmet need for a means of electrically insulating a firing pin, as well as an electrically insulated firing pin, for use in an electronic firearm for firing electrically activated ammunition.
SUMMARY OF THE INVENTION

The present invention provides a means of electrically insulating a firing pin or portions thereof, as well as an electrically insulated firing pin, for use in an electronic firearm for firing electrically activated ammunition.

Specifically, the present invention provides, in a firing pin for a firearm adapted for use with electrically activated ammunition, the improvement wherein the firing pin comprises at least one portion positioned to insulate the firing pin from at least one adjacent conductive surface of the firearm.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a side elevational view of an embodiment of a firing pin of the present invention adapted for use in an electronic bolt action rifle.

Figure 2 is a cross sectional view of the forward end of the firing pin of Figure 1.

DETAILED DESCRIPTION OF THE INVENTION

The present invention will be more fully understood by reference to the figures. Variations and modifications of the present invention can be substituted without departing from the principles of the invention, as will be evident to those skilled in the art. For example, in addition to the many possible configurations of the firing pin, the firing pin of the present invention can be used in a wide variety of firearms. The configuration of the firing pin will vary according to the type of firearm in which it is utilized, as well as according to the type of action in which the firing pin operates. For example, a firing pin for use in a handgun will have a different configuration from a firing pin for use in a rifle or shotgun. Similarly, a firing pin for use in a bolt action rifle will differ from a firing pin for use in a semi-automatic rifle. As will be evident to those skilled in the art, the firing pins of the present invention can be modified for use in any type
of electronic firearm designed specifically or adapted for use with electrically activated ammunition.

In Figure 1, an embodiment of the firing pin 1 of the present invention is illustrated with an electrically insulating portion 2 shown as stippling on the forward end of the firing pin. The electrically insulating portion does not extend to or insulate the firing pin at a forward conductive end 1A and rearward conductive area 1B. The forward conductive end is positioned to transmit voltage to a round of ammunition within the firearm in which the present firing pin is to be utilized, and the rearward conductive area is positioned to receive voltage from an energy source operatively connected to a trigger assembly and activated when the trigger is pulled.

In alternate configurations, the firing pins of the present invention can comprise electrically insulated portions at the rearward conductive area, depending upon the type of action and trigger assembly to be utilized, so that the rear of the firing pin is electrically insulated from receiving energy from a power source or through the trigger assembly unless it is in the correct position. In the embodiment shown in Figure 1, which is adapted for use in a bolt assembly of the type disclosed in the parent of the present application, U.S. Patent Application Serial No. 08/713,676, there is no need for an additional insulated area at the rearward end of the firing pin, as the electrical contact assembly will electrically isolate the rearward area of the firing pin from receiving any power when the bolt is in the open or closed and unlocked positions.

In embodiments of the present invention for use in a bolt action rifle of the general type disclosed in the parent application, Serial No. 08/713,676, wherein the insulated portion of the firing pin of Figure 1 comprises a coating, it is preferred that the coating be applied up to the radius of the conductive forward end of the firing pin. Figure 2 shows a cross section of the forward end of a firing pin of the present invention, wherein the firing pin is
adapted for use in a bolt assembly 3. The insulating portions of the firing pin are shown on the sides of the cross section of the firing pin, and extend along an arc towards the tip of the firing pin. By coating the forward end of the firing pin up to the radius of the firing pin tip or forward conductive end, the likelihood that the coating will be chipped or worn due to contact with the bolt face or other portion of the bolt assembly will be reduced. Accordingly, it is important to provide a coating that does not comprise a sharp edge that is likely to contact another surface.

Within the broad parameters described above, the electrical insulation means can vary widely, and can comprise an electrically insulating surface coating on the firing pin, or a surface modification of the firing pin. Coating materials which can be used for the firing pin include, but are not limited to, amorphous diamond, metal matrix composites, high temperature composites, or ceramics. Of the many known ceramics that can be used, those found to be particularly satisfactory include alumina, mixed aluminas (e.g. with titania, magnesia, or zirconia) and magnesia stabilized zirconia. Of these, magnesia stabilized zirconia is especially preferred due to its superior resistance to wear. Surface modification of the firing pin which can be used in the present invention include, for example, ion implantation. Still other coatings, treatments, and surface modifications for the firing pin will be evident to those skilled in the art.

A preferred method of insulating the firing pin involves coating the portion or portions of the firing pin to be insulated with a ceramic coating of magnesia stabilized zirconia. The thickness of the coating to be applied will depend on the electrical requirements of the ammunition utilized in the firearm, as well as the design of the firearm, the wear characteristics of its action, and the characteristics of the power supply and safety systems of the firearm. For example, if the ammunition can be activated by 150 volts, the insulative coating should resist break down when the voltage is applied to the firing pin to activate
the round of ammunition. For example, if the coating is 0.010 inch thick, the material should have a minimum dielectric strength of 15,000 volts per inch (150 volts per 0.010 inch) to withstand the applied voltage without breaking down.

Breakdown of the ceramic coating can occur when the applied voltage exceeds the dielectric strength of the coating. When the dielectric strength of the coating is exceeded, the voltage arcs through the coating, causing rapid localized heating of the substrate, or in the present invention the firing pin, in the vicinity of the arc. The effect of the rapid localized heating can cause the substrate material to violently melt, destroying the coating and splattering the melted substrate material onto the surrounding coated areas. In general, magnesia stabilized zirconia has been found to have a minimum dielectric strength in excess of 140,000 volts per inch. For firing pins of the present invention which are adapted for use in electronic firearms of the type disclosed in Serial No. 08/680,490, a 0.005 inch thick layer of magnesia stabilized zirconia applied to the exterior surface of the firing pin has been found to be especially satisfactory. The above described plasma applied ceramic coatings have been found to resist failure or breakdown even after repeated use.

A variety of coating techniques can be used to apply a ceramic coating to the firing pin of the present invention. The coated portion of the firing pin should include the portions that contact any adjacent conductive surface, but should not include the forward tip of the firing pin. In embodiments for use in a bolt action rifle, these surfaces include the bolt body and bolt assembly. As discussed above, the boundaries of the coated portions should not be positioned to contact any adjacent parts of the firearm, and the coated portion should extend beyond such contact prone areas to avoid possible chipping of the coating due to repeated contact with other parts of the firearm.

The firing pin should be manufactured to allow for any increased diameter of the resulting coated portion. The firing pin can be manufactured
from a wide variety of conductive materials. It is preferred that the firing pin be fabricated from steel, especially stainless steel, but other materials will be evident to those skilled in the art. It is also preferred that the firing pin be pre-treated with an intermediate coating to improve adhesion of the ceramic to the firing pin.

A preferred intermediate coating is nickel, which adheres well to steel and to the ceramic coating. The nickel intermediate coating and the ceramic coating can be applied using the same equipment as a “grade-coating,” by depositing pure nickel to form the intermediate layer, then depositing a continuously varying mixture of nickel and ceramic, and finally depositing pure ceramic by plasma spray processing.

Plasma spraying involves a gaseous collection of electrons, ions, and neutral molecules, preferably controlled at a density sufficiently high so that the electrons readily exchange energy with the ions and neutral molecules to yield a kinetic energy high enough to melt any of the materials discussed herein. The plasma can be contained within a typical plasma gun, operated with direct current, and containing a water cooled cathode and anode. The plasma gas, usually inert, is initiated into the plasma stage by an electrical arc between the anode and cathode, exiting the plasma gun as a flaming ionized plasma gas which tends to recombine to become neutral as it exits the plasma gun. As the plasma gas recombines, it yields a high level of enthalpy. In the area where the recombination occurs, a feedstock powder is introduced, carried by the flaming gas, melted, and impacted onto the firing pin, where it rapidly solidifies. In a 40kW plasma gun, a feedstock such as alumina can be fed into the recombination area at ranges from 2 to 5 kg/hr and higher. Higher power plasma spray guns yield higher throughputs.

The physical features of the feedstock powder used in plasma coating are important, as they relate to the quality of the coating. For example, a flake shaped powder will typically not display smooth flow, resulting in a
discontinuous, pulsing stream of powder into the flame, leading to a non-uniform stream of molten particles, and thus an uneven coating. An uneven coating will result in uneven insulating characteristics, and thus it is important to provide a coating that is uniform. Accordingly, feedstocks comprising spherical particles are preferred for their smooth uniform feeding into the flame, and resulting in a deposit with fewer discontinuities.

The specific process of plasma spray coating the firing pin will vary according to the materials chosen, the type of deposition equipment, the desired thickness of the coating, and the type of intermediate coating selected. In addition, the process will vary according to the technology employed in the spraying process, as the art of plasma spraying continues to be dependent on the skill of the spray gun operator, rather than the technology employed. Advancements in the technological aspects of plasma spraying continue through computer assisted statistical process control of robotic plasma sprayers.

Other ceramic coatings which can be used, such as the various alumina based ceramics, should resist wear from the forces associated with the activation of a round of ammunition in the chamber of a firearm, in close proximity to the firing pin, while providing the needed dielectric strength to reduce the likelihood that the insulative coating will break down. Typically, alumina is generally less resistant to failure or breakdown than the magnesia stabilized zirconia coating described above.

Amorphous diamond coating of the firing pin has also been found to be a durable and failure resistant means of electrically isolating the firing pin. The amorphous diamond coating can be applied by physical vapor deposition or chemical vapor deposition.

Another coating which can be used for the firing pin includes a diamond-like nanocomposite coating. The diamond-like nanocomposite coating can be applied by plasma/ion beam deposition of two random impenetrating
networks of carbon stabilized by hydrogen and silicon stabilized by oxygen, tailored by the introduction of ceramic ions into the network structure.

In addition to the various coated firing pins discussed above, the firing pins of the present invention can comprise portions having an insulating surface modification. The surface of the firing pin can be modified by ion implantation of nitrogen atoms into the steel surface, creating an Epsilon layer which is resistant to wear and electrically insulative. For firing pins of the present invention adapted for use with the electronic firearm having a bolt assembly of the general type disclosed in the parent of the present application, U.S. Patent Application Serial No. 08/713,676, the ion nitriding of the surface should result in an Epsilon layer of a thickness of at least about 0.002 inch. The process of ion implantation is less preferred, due to the time requirements inherent in the process, in applications requiring mass production or short production times.

The firing pins of the present invention provide a desirable combination of advantages. Specifically, when used in a firearm for firing electrically activated ammunition, the present invention provides a more reliable means of electrically activating ammunition within the chamber of a firearm.

When the present firing pin is adapted for use in a bolt action rifle of the type discussed above, the movable configuration of the bolt assembly permits the firing pin to transmit power to ammunition within the chamber only if the bolt assembly is in the closed and locked position. Unlike previous insulating techniques and materials, the present invention resists failure and breakdown, as it provides an insulated surface that is less susceptible to the forces, heat, and gases that are associated with the activation of ammunition.
WE CLAIM:

1. In a firing pin for a firearm adapted for use with electrically activated ammunition, the improvement wherein the firing pin comprises at least one portion positioned to insulate the firing pin from at least one adjacent conductive surface of the firearm.

2. A firing pin of Claim 1 wherein the at least one electrically insulating portion of the firing pin comprises a modified surface layer.

3. A firing pin of Claim 2 wherein the surface layer is modified by ion implantation.

4. A firing pin of Claim 3 wherein the surface layer is modified by ion implantation of nitrogen.

5. A firing pin of Claim 1 wherein the at least one electrically insulating portion of the firing pin comprises a coating.

6. A firing pin of Claim 5 wherein the coating comprises amorphous diamond.

7. A firing pin of Claim 5 wherein the coating comprises ceramic.

8. A firing pin of Claim 7 wherein the ceramic is selected from the group consisting of alumina and magnesia stabilized zirconia.

9. A firing pin of Claim 8 wherein the ceramic consists essentially of magnesia stabilized zirconia.

10. A firing pin of Claim 7 wherein the ceramic comprises at least one alumina based ceramic.

11. A firing pin of Claim 10 wherein the alumina based ceramic further comprises at least one selected from the group consisting of titania, magnesia, and zirconia.
A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : F41A 19/58
US Cl. : 42/84; 89/28.05
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 42/84; 89/28.05

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS, search terms: insulation, ceramic, amorphous diamond, magnesium, zirconia, titania, ion implantation, nitrogen

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C. See patent family annex.

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Date of the actual completion of the international search

28 OCTOBER 1997

Date of mailing of the international search report

16 DEC 1997

Name and mailing address of the ISA/US Commissioner of Patents and Trademarks

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