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SMOKELESS POWDER

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This invention relates to an improved smokeless powder of the progressive burning type. More specifically it pertains to a smokeless powder grain which is progressive burning and capable of being ignited readily, and to a method of producing said grain.

Existing surface modified powders are characterized by several disadvantages. In the first place double base powders do not possess the desired stability. Secondly, smokeless powders, generally, in large diameters are frequently subject to "hang fires."

The object of this invention is a novel smokeless powder which is not subject to "hang fires" when employed in large diameters. A further object is a novel smokeless powder which is progressive in burning, and a method of producing the same. Another object is a smokeless powder which maintains its progressive-burning characteristics over long storage intervals. A further object is a novel method of coating smokeless powder. A still further object is a grain coated with a deterrent which is capable of retarding combustion and which does not diffuse and migrate toward the center of the grain. Other objects will become apparent as the invention is described in detail hereinafter.

We have found that the foregoing objects are attained by our process which comprises coating a freshly-formed string of smokeless powder and subsequently cutting said coated string to form grains. The latter will thus be coated only on their outer surfaces and not on their ends or within the perforations therethrough. Any suitable coating agent may be employed including dinitrotoluene, diethyl diphenyl urea, and various phthalates. However, we prefer to employ an agent of high molecular weight, which agent is substantially non-soluble in nitrocellulose or nitroglycerin, but is compatible therewith and adheres firmly to the powder grain. Such preferred agents are incapable of supporting their own combustion, but are consumed during the combustion of the powder charge. They are, moreover, substantially non-volatile and stable under atmospheric conditions.

Among the agents which have proved preferable are various methacrylic ester polymers, particularly the lower alkyl esters of polymethacrylic acid, such as the methyl, ethyl, n-propyl, n-butyl, and isobutyl esters. These esters of methacrylic acid are tough and hard, and remain on the surfaces to which they have been applied. Likewise, the chitin compound known commercially as Daktose may be employed.

Due to the nature of these agents, they not only are very effective in retarding combustion, but in addition they tend to render the coated powder more difficult to ignite. It is to obviate

this disadvantage that we coat a string or strip of the green smokeless powder before the string is cut into grains of the desired length. The severing of the string to form grains thus exposes the end surfaces, which are uncoated. We have found that, by permitting these surfaces to remain uncoated, it is possible to effect ignition of the powder very readily by means of the ordinary percussion primers currently employed, even though the outer surface of the grain is coated with a material which is a very effective combustion retardant. Thus "hang fires" in larger diameters are eliminated. Moreover, such grains upon combustion yield a progressive burning.

It will be understood that the strip or string of smokeless powder may be coated in any convenient manner, for instance by subjecting it to the action of a solution containing the coating agent, or to the coating agent in molten condition, and the like. However, we prefer to coat a string of powder by passing it through an aqueous emulsion containing the coating agent in solution in a suitable solvent, because such procedure not only is conducive to the formation of a uniform coating on the powder string, but in addition the amount of material added as a coating may be regulated without undue difficulty. The time required for coating the powder depends on various factors, such as the amount of coating desired, the type of coating, the temperature and concentration of the emulsion, etc., but these factors can be determined empirically for any desired conditions. After the powder has been exposed to the coating emulsion for the requisite time interval, it is removed and dried, in order that the coating may be set or fixed thereto. In case the powder string is green, that is to say, if it contains a large quantity of solvent, the coated string is dried in equipment adapted to permit the recovery of the solvent evolved therefrom. After drying, the coated string is cut in the usual manner, to yield grains of desired length. These may be dried further and glazed according to known manner.

A smokeless powder manufactured in accordance with the present invention is illustrated in the following examples.

Example I

A smokeless powder composed of 73.4 parts nitrocellulose of 13.2% nitrogen content, 25 parts of nitroglycerin, 1.0 part potassium sulfate, and 0.6 part of diphenylamine was colloided by mingling these ingredients with solvents according to known procedure. The colloided mass was then extruded from a press through dies designed to yield a string of green powder having an outside diameter of 0.080 inch and having a perforation

0.015 inch in diameter, said perforation extending longitudinally through the center of said string. The resultant strings were immersed in a mixture comprising a stabilized 40% emulsion of butyl methacrylate and water. After a preliminary drying, the coated strings were cut into grains 0.091 inch in length. Analyses of the finished powder revealed that it was coated with approximately 6 parts of the butyl methacrylate. When this powder was compared with a powder of the same composition but which had not been coated by firing in a bomb connected in a cathode ray oscillograph circuit provided with a piezo-electric gauge for converting the mechanical impulse to an electric one, the graphs obtained showed that, when the powder charges were one-quarter consumed, the presence of the coating caused a decrease in the burning rate of 48%.

Since a progressive burning powder is one wherein the burning speed is retarded during the early stages but not in the latter stages of combustion, so that in effect the rate of pressure development is altered, it follows that the progressivity of burning of powders can be determined by comparing their burning speed at the same point of consumption during the early stages of the combustion of the powders. Likewise, any change in the rate of pressure development occurring during storage of the powder may be ascertained by measuring the rate of pressure development at any of the early stages of combustion.

The stability of the ballistic performance of powders made in accordance with the present invention is illustrated by the following example.

Example II

Two samples of powder were coated, the powder composition and granulation being identical with that set forth in Example I. The samples were coated with 4 and 6 parts of butyl methacrylate. The finished, coated powders were tested as soon as made, and then were stored for 22 days at a temperature of 50° C., at which time they were again tested in order to determine any change in rate of pressure development. The results are shown in the following.

Powder	Effect of storage on rate of pressure development
	Per cent
A (coated—4 pts. butyl methacrylate)	+4.1
B (coated—6 pts. butyl methacrylate)	+2.9

The foregoing results show that powders coated with an insoluble, non-explosive material

such as butyl methacrylate exhibit very little change in the rate of pressure development, even though they are subjected to extreme storage conditions. It is evident that the stability of ballistic performance is completely satisfactory with powders of the type disclosed herein.

Our powder possesses the advantage that even though the powder grains are coated with a substantially non-volatile, non-explosive material, ignition thereof may be effected readily because the entire surfaces of the grains are not coated. The ease of ignition which characterizes these powders is surprising, when viewed from the standpoint of the nature of the preferred coating materials. Furthermore, regardless of the coating materials employed, "hang fires" in large diameter are eliminated.

Furthermore, our preferred powders, namely those coated with agents of high molecular weight as described in the foregoing, possess the additional advantage over conventional powders that they exhibit a stability of ballistic performance which is vastly superior to that characterizing the double base smokeless powders currently manufactured, while simultaneously yielding a burning which is truly progressive in character. Consequently, it follows that said powders may be employed after substantial periods of storage without danger that the powder has become "quicker" and thus may cause injury because of changes in burning characteristics which have occurred during storage.

Although our invention has been described in detail, variations may be made without departing from the spirit or scope thereof. We intend, therefore, to be limited only in accordance with the following claims.

We claim:

1. A progressive-burning smokeless powder charge comprising grains of the pressed and cut type surface coated with an organic material of high molecular weight not in itself explosive and substantially non-soluble and non-diffusible in the organic nitrates of the nitrocellulose composition.

2. The progressive-burning smokeless powder grain of claim 1 in which the organic material of high molecular weight is a methacrylic ester polymer.

3. The progressive-burning smokeless powder grain of claim 1 in which the organic material of high molecular weight is butyl methacrylate.

4. The progressive-burning smokeless powder grain of claim 1 in which the organic material of high molecular weight comprises a water-soluble chitin.

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