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2,320,243

SMOKELESS POWDER COMPOSITION

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Fig. 1

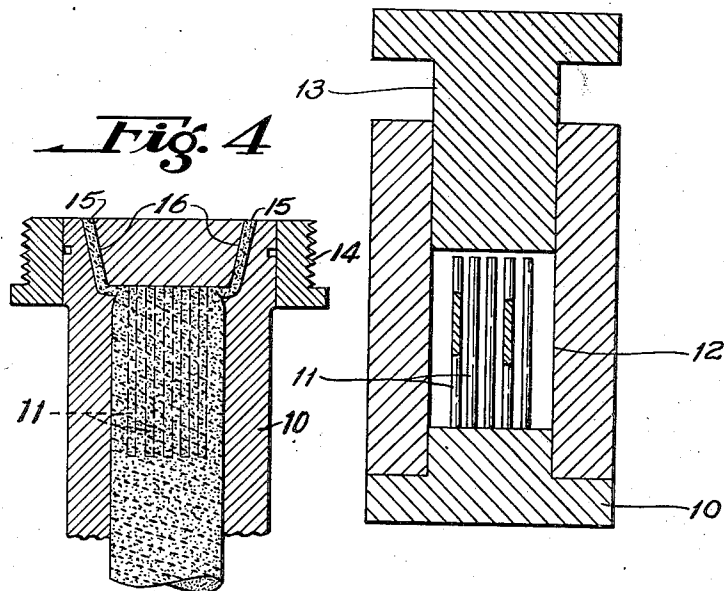


Fig. 4

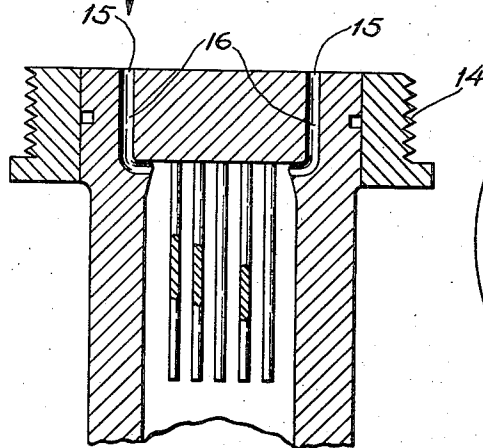
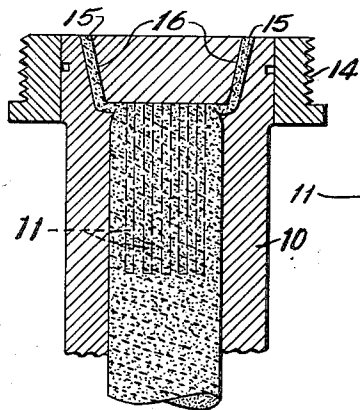


Fig. 2

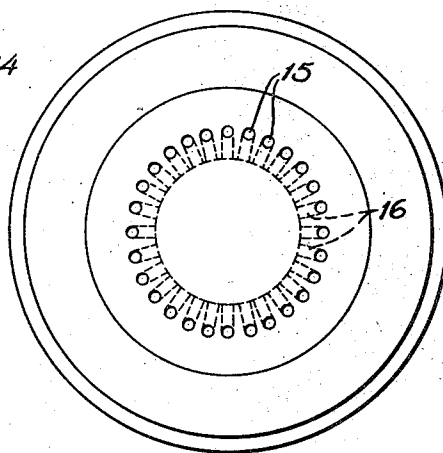


Fig. 3

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SMOKELESS POWDER COMPOSITION

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326,162. Divided and this application Septem-
ber 28, 1940, Serial No. 358,774

3 Claims. (Cl. 102—98)

This invention pertains to a smokeless powder having novel physical characteristics, and more particularly to such smokeless powder in the form of grains having definite dimensions.

This application is a division of my co-pending application Serial No. 326,162, filed March 27, 1940, and contains matter divided out of said co-pending application.

Smokeless powder is usually produced as grains of predetermined size and shape because of the fact that such grains permit some control over the burning of the powder and consequently of its ballistic performance. Often perforations of predetermined size extend through the powder grains, said perforations being designed to afford an increase in the burning surface as combustion progresses.

Heretofore, smokeless powders of this type have been produced by forcing a colloid of suitable composition through one or more dies in a press, the colloid issuing therefrom in the form of perforated strands or strings. This process has been characterized by the flow of the colloid in a single direction only. Thus, although many dies of widely varying structure have been employed, all of them permit a substantially straight flow of the colloid through the die. After issuing from such dies, the strings of colloid are fed to a cutting machine adjusted to cut segments of the desired length. The "green" powder grains are then treated in a system which permits recovery of the major part of the solvent, following which they are dried. The resulting conventional powder grains invariably exhibit two outstanding defective characteristics: First, the grain has shrunk much more across the diameter or web than it has in length; second, upon impact the grain shows a cleavage along a line parallel to the longitudinal axis of the grain, rather than across its diameter.

These characteristics are undesirable because the proper ballistic performance of the powder is dependent upon the grains remaining as integral units during the combustion of the charge, rather than breaking into fragments, since fragmentation of said grains exposes a burning surface exceeding that calculated as desirable, with the result that erratic ballistic performance may be obtained. Various attempts have been made to overcome this undesirable phenomenon, said attempts being directed to a composition better able to withstand the pressures developed, and also to charges of such design that fragmentation will be less apt to occur. Thus, varying amounts of guncotton and pyro-cellulose have

been blended in order to obtain a tougher composition. Likewise, different solvents have been employed and numerous additional ingredients have been incorporated in the composition for this purpose. In addition, experiments have been made wherein the powder charge was arranged with respect to the ignition charge in order to prevent travel of the charge, as by spacers for example, so that fragmentation would be eliminated or at least diminished appreciably.

The foregoing modifications have in general effected an improvement, but in no case can conventional powder be fired with the assurance that fragmentation and consequent erratic ballistic results will be avoided.

The object of the present invention is a smokeless grain of superior physical strength. Another object is a smokeless powder granulated to definite dimensions which possesses a greater resistance to impact than that of any such powder grain heretofore known to the art. A further object is a smokeless powder grain which, upon the removal of solvent therefrom, shrinks substantially uniformly in all dimensions. Other objects will become apparent as this invention is described more fully hereinafter.

I have found that the foregoing objects are accomplished by means of a smokeless powder grain having a random or improved orientation of the particles of material of which the grain is composed. The method of forming such a grain is disclosed more in detail in the original application which has been referred to hereinbefore.

I have found that the two undesirable characteristics mentioned hereinabove, namely the uneven shrinkage and extreme frangibility, can be overcome through the particle orientation achieved if, while forming the grain, I prevent flow of the colloid in one direction only. Thus, if in the formation of the final grain the colloid be moved in a helical or concentric path, the behavior of the finished grain is altered remarkably. The particles then are not aligned in one direction only, but rather point in numerous directions lying at various angles in many different planes. This disarray of particles I call "random orientation," and this term is used in this sense throughout the description of the invention. The grains whose particles have this property are characterized by uniform shrinkage and materially increased impact resistance.

My invention may be more readily understood by referring to the accompanying drawing.

Similar numerals refer to similar parts throughout the several views.

Referring in general to the various figures of the drawings, Fig. 1 is a cross-sectional view in elevation of a die mold adapted to form a grain of the type disclosed in the present invention. Fig. 2 is a cross-sectional view in elevation of a die adapted to the continuous formation of a string of colloid which possesses random orientation. Fig. 3 is a plan view of the same. Fig. 4 is a view in cross-section of a string of powder as it is formed when using a die of the type set forth in Figs. 2 and 3.

The following example refers in greater detail to a comparison of the prior art method and the present inventive method of forming smokeless powder grains.

Example

A solvent-containing smokeless powder dough is macerated, pressed into a block, and the block extruded through small orifices, thereby forming the material into strings. A portion of these strings was pressed and extruded through the conventional type of die. The colloid was forced by pressure through the openings of the die head and moved along and about the pins and the inner walls of the die body, the entire assembly being cooled by means of water flowing through the jacket. The cooling water enters the jacket through the entry and exits through, said jacket being made a closed system, except for the entry and exit, by means of plug. Attachment of the assembly to the press was effected by means of the threads. In the case of this particular powder, the die employed had 7 pins and was constructed to produce a grain of the following dimensions:

D (over-all diameter, d (diameter of perforations), 1.105" 0.106"
IW (inner web), 0.285" OW (outer web), 0.182"

The length of the powder grain was 1.90".

The second portion of the colloid was divided into predetermined quantities and charged into die molds of the type shown in Fig. 1, wherein 10 represents a die head having the die pins 11, said die head fitting snugly within the walls 12. Pressure was applied by appropriate means via the piston 13. The particular die molds employed were designed to yield a green smokeless powder grain having dimensions identical with those produced above. Thus, grains having identical size and shape were produced, the sole difference being in the actual formation of the final grain. Both types of grains were dried under identical conditions to the same content of volatile material, and were then measured to determine the shrinkage of the various dimensions. The amount of shrinkage determined by measurement of numerous grains is as follows:

Grains	Shrinkage
A Grains formed in usual manner...	Length..... Per cent 4.10
	D..... 21.61
	d 27.59
	IW..... 35.01
	OW..... 27.14
	Length..... 19.4
B Molded grains.....	D..... 19.8
	d 20.1
	IW..... 22.2
	OW..... 20.4

The foregoing data reveal that the A type grains shrank over 5 times as much in diameter

as they did in length, whereas the molded grains (type B) showed that the shrinkage in diameter was approximately equal to that in length.

Grains of the present invention exhibited a strikingly large increase over the ordinary powder grains with respect to resistance to impact. This was shown by a test wherein the dried A and B grains were placed on a smooth metal surface, and flat metal weights were permitted to fall on the grains in that position. In order to eliminate possible irregularities in the grains, $\frac{1}{2}$ " sections were taken from each grain, and these sections subjected to the test. The results were as follows:

Grains	Wt. of falling metal	Distance required to crack grains
	Pounds	
A.....	0.5	26-30".
	1.0	13-14".
B.....	0.5	No breakage-69" max. ht.
	1.0	45-69".

¹ Some grains failed to break when the weight was dropped from the maximum height of 69 inches.

In conducting the foregoing impact tests, it was noted that the A grains almost invariably cracked along the longitudinal plane regardless of the position in which the grains were placed. Whether they were placed with the cross-section uppermost or to one side made no difference. The line of cleavage shown was clean-cut and definite. However, the B grains broke irregularly in a jagged line along no particular plane. The superior resistance of the B grains is shown conclusively by the results tabulated above, these grains having about 5 times the impact resistance of the usual grain.

Figures 2 and 3 show in detail a die adapted for the formation of the smokeless powder of the present invention. The colloid is forced through the orifices 15, these being curved so that the material enters the section in which the pins are located, at almost right angles to the longitudinal dimension of the pins. The path of these orifices is indicated by the dotted lines 16. Although only one series of orifices is shown (Fig. 4), it is clear that more can be added if desired. Referring to Fig. 4, it may be seen that the particles of the smokeless powder colloid, due to the direction in which they are forced in the die, take a path which is helical or concentric, so that the string of powder is composed of particles which have been aligned in one direction only, since in moving through the die they are forced in a tortuous path, which is indicated by the fine lines representing the smokeless powder colloid.

The fact that prevention of streamlined flow of the colloid during formation of the powder grain should cause the properties of the finished powder grain to be different is very surprising, in view of the fact that the usual manufacture of smokeless powder entails working of the colloid to a considerable extent prior to final formation of the grain. Thus, the solvent-laden colloid is thoroughly mixed, macerated, pressed in a blocking press, and then extruded through small orifices prior to its extrusion in final form. Due to this rather extreme treatment, it was commonly believed that the fibrous structure of the nitro-cellulose had been substantially destroyed and that the colloid was essentially homogeneous. Therefore, it was natural, in the absence of explanation, to consider the non-uniform shrink-

age and the definite cleavage along the longitudinal axis of the grain as inherent characteristics of smokeless powder. That this is not true is demonstrated by the fact that powder grains made in accordance with the present invention, differing from the usual powder grains in that they are composed of particles having random orientation, also exhibit very different physical characteristics. These characteristics include uniform shrinkage of the powder grain in all dimensions upon removal of the solvent therefrom, increased resistance to impact, and an irregular cleavage pattern.

By producing a powder having an impact resistance far superior to that of powders of similar shape and composition, it is possible to decrease, and in many cases to eliminate, the fragmentation of smokeless powder charges which occurs upon initiation. Moreover, the grains of the present invention, although they do exhibit very different physical characteristics from the smokeless powder grains known heretofore before ignition, show no substantial change with respect to burning. It follows, therefore, that the erratic ballistic performance due to the fragmentation of the powder grains may be proportionately reduced or eliminated. Likewise, the adoption of grains of this type obviates the necessity of exercising some of the precautions heretofore taken to keep fragmentation to the

minimum possible degree, such as spacing of the charge for example.

It will be evident to those skilled in the smokeless powder art that the foregoing description permits of variations without departing from the spirit or scope of the invention. I intend, therefore, to be limited only in accordance with the following patent claims.

I claim:

1. In a smokeless powder charge adapted to resist fragmentation upon initiation, a grain of definite dimensions which possess a random orientation of the particles thereof.

2. In a smokeless powder charge adapted to resist fragmentation upon initiation, a grain pressed to definite dimensions, said grain possessing a random orientation of the particles thereof and having a resistance to impact materially greater than grains of similar composition which have been extruded through a die imparting streamline flow.

3. A powder grain of definite dimensions, having random orientation of the particles of which it is composed, said grain having been shrunk substantially uniformly in all dimensions, and having a resistance to impact materially greater than grains of similar composition wherein there is alignment of the composition particles in substantially one direction.

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