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(54) METHOD FOR PRODUCTION OF NITROCELLULOSE BASE FOR CONSOLIDATED CHARGES AND CONSOLIDATED PROPELLANT CHARGE BASED THEREON

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(57) **ABSTRACT**

METHOD FOR PRODUCTION OF NITROCELLULOSE BASE FOR CONSOLIDATED CHARGES includes nitrating fine-fiber cellulose stuff to obtain predetermined concentration of nitrogen in the prepared nitrocellulose, removing impurities and excess of moisture from the nitrocellulose pulp, grinding the fibers and transferring the disperse stock to production of consolidated charges In order to reduce risks in production of non-plasticized nitrocellulose base and obtain porous consolidated charges having felt structure the nitrocellulose pulp is dried prior to grinding, then grinded to obtaining polydisperse mixture of fibrous particles of which mixture consolidated charges are formed.

CONSOLIDATED PROPELLANT CHARGE BASED THEREON.

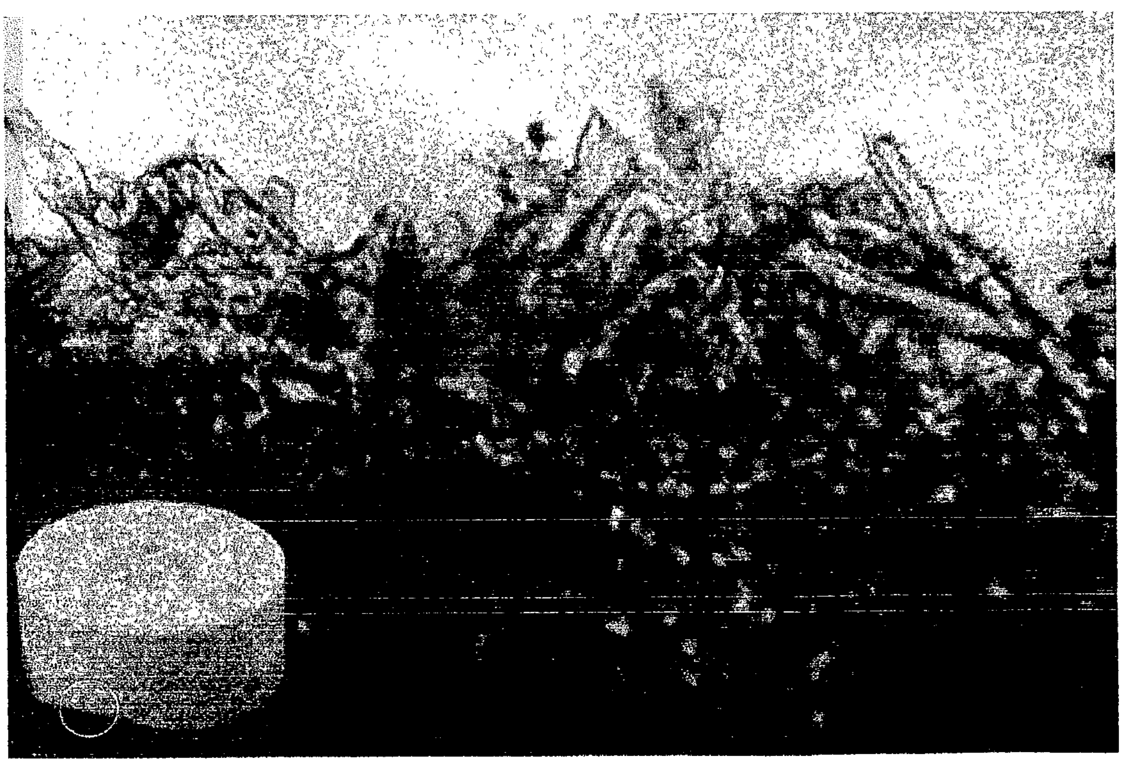

fig. 1

fig. 2

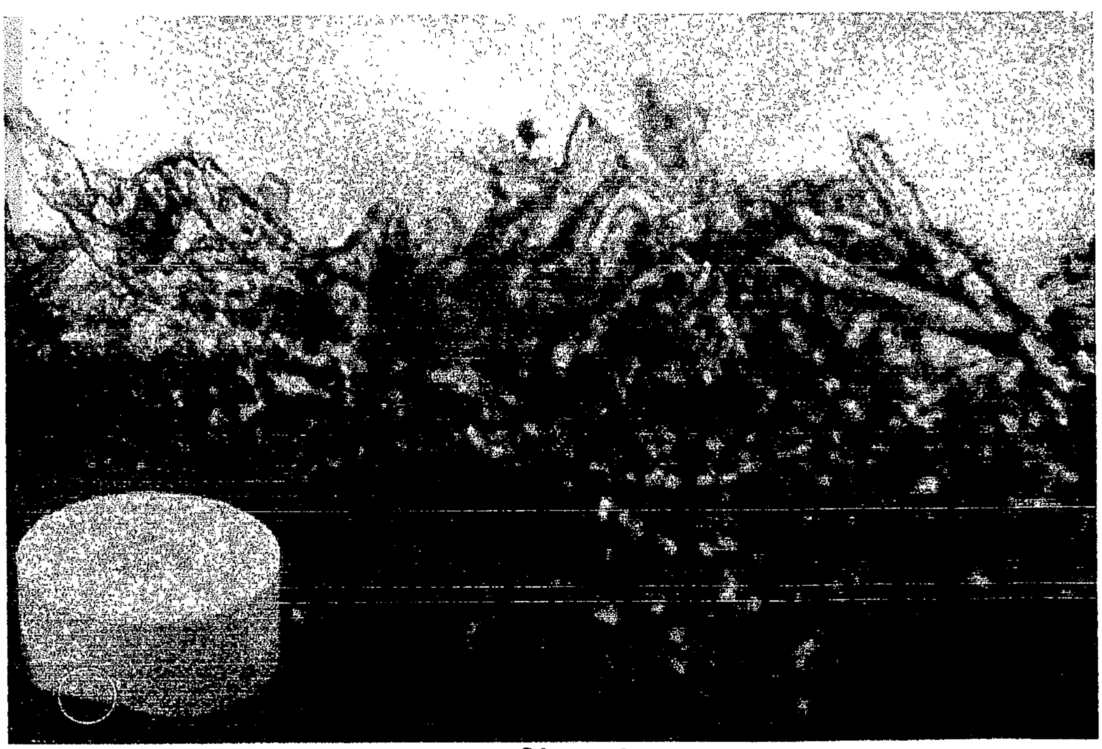

fig. 3

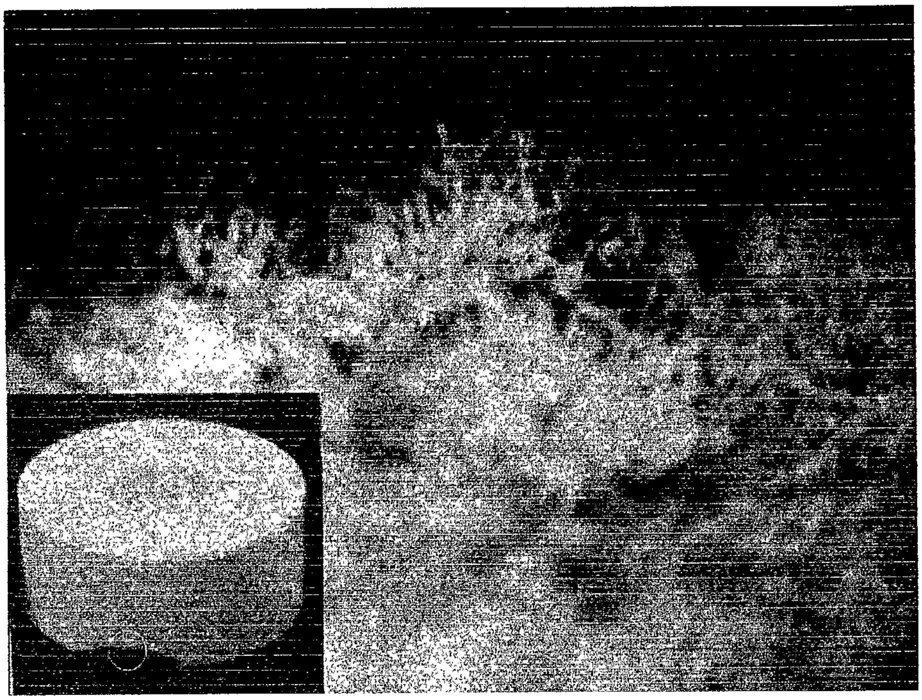

fig. 4

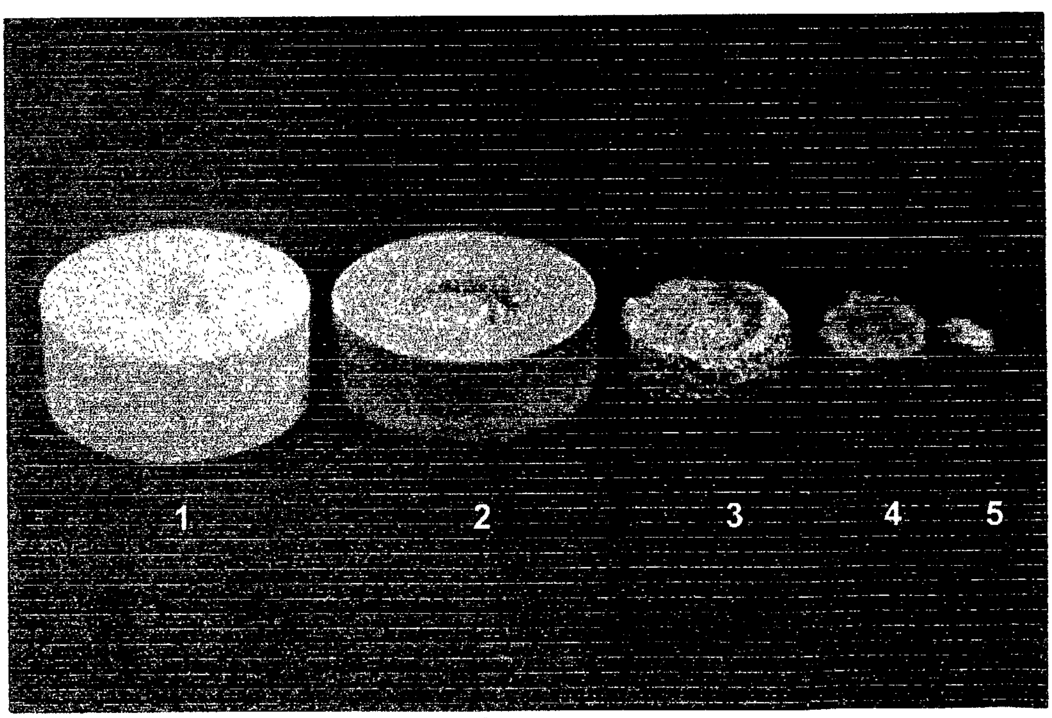


fig. 5

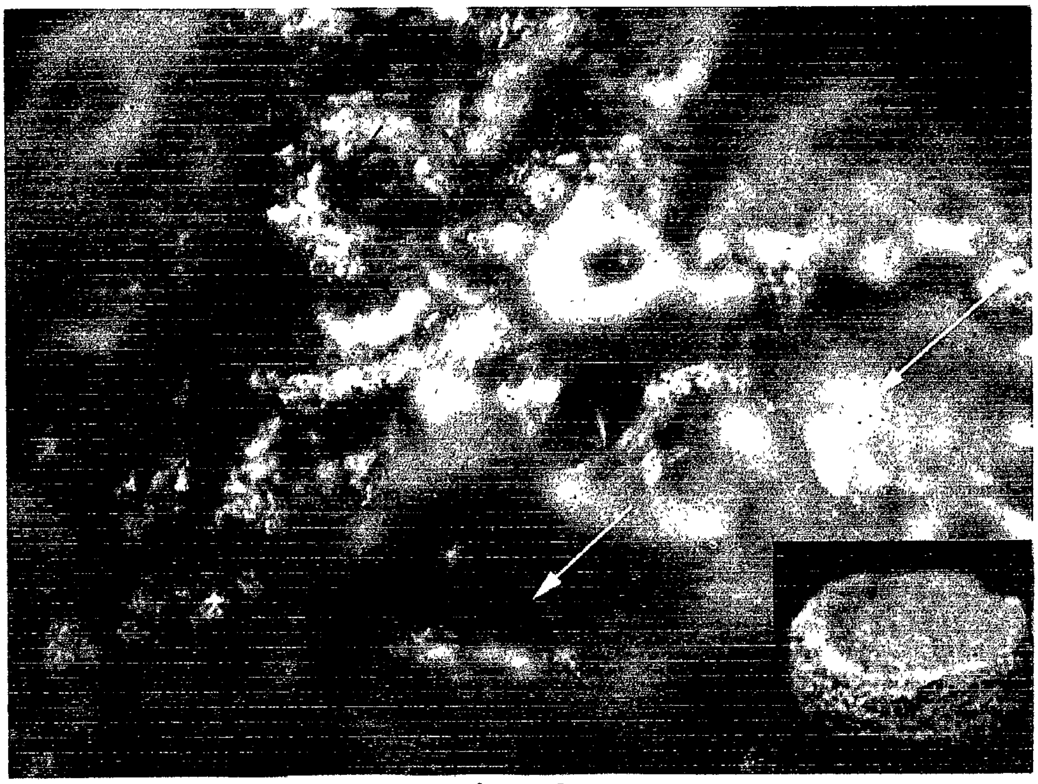

Fig. 6

# METHOD FOR PRODUCTION OF NITROCELLULOSE BASE FOR CONSOLIDATED CHARGES AND CONSOLIDATED PROPELLANT CHARGE BASED THEREON

## FIELD OF INVENTION

**[0001]** This invention relates to:

**[0002]** method for production of nitrocellulose (NC hereafter) base for consolidated charges particularly for guns, such as hunting rifles, construction-and-erection guns (particularly for driving nails, dowels, and tie cotters), means for projecting bodies made of signaling or pyrotechnic compositions, sporting guns and pistols of arbitrary caliber and

**[0003]** to structure and physical-and-chemical properties of consolidated charges, particularly propellant charges based thereon.

## BACKGROUND ART

**[0004]** It is known that propellant charges for guns are products of mass production and mass consumption. Generally, they are in the form of mass-fixed amounts of suitable granulated NC gunpowder (preferably pyroxylin powder). These amounts are either pre-filled inside the fixed ammunition, or may be supplied to the market in standard packages for consumers who prefer to charge their cartridges themselves or for separate-loading ammunition.

**[0005]** Accordingly, propellant charges must comply with a complex of requirements that are getting more and more stringent and are difficult to combine, of which the most important are the following:

**[0006]** as high as possible safety of production, storage and utilization;

**[0007]** availability for broad sections of consumers;

**[0008]** as high as possible ballistic efficiency rated (with other conditions being equal) in amount of muzzle velocity of flight of projectiles (shots, bullets, nails or dowels, shells etc.) which can be developed at a given maximum allowable value of pressure of powder gases in the barrel of a certain gun; and

**[0009]** as high as possible reproducibility of ballistic characteristics from one shot to another.

**[0010]** Other parameters can be taken into account, such as chemical stability of propellant charges after long-term storage of ammunition charged with such charges and the level of dependence of ballistic characteristics on ambient temperature.

**[0011]** Moreover, the method for producing such charges must be simple and safe for personnel and the environment and as much resource saving as possible.

**[0012]** The requirements to propellant charges and methods for their production are closely interconnected. However, only individual fulfillment of these requirements does not present difficulties.

**[0013]** Thus, generally known are traditional methods for nitration of cellulose and mass production of loose powder of plasticized NC developed long time ago. Stringent safety measures are provided at each step of these methods. Therefore, spontaneous explosions of prepared raw materials and ready products during their production, storage and usage are possible only when standard conditions of operation are violated (see, e.g., часть II "Пороха и заряды" книги: Будников М.А., Левкович Н.А., Быстров И.В. и др. «Взрывчатые вещества и пороха». - Москва: Гос. изд-во оборонной промышленности, 1955 - Part II "Powders and Charges"in the book by Budnikov M. A., Levkovich N. A., Bystrov I. V. et al. "Vzryvchatyje Veshchestva i Porokha"Chast II. Moscow, Gos. lzdatelstvo Oboronnoi Promyshlennosti—State Publishing House of Defense Industry, 1955).

**[0014]** Further, utilization of cellulose of different origin (particularly cotton pulp and sometimes wood cellulose), adjustment of the degree of its nitration, utilization of plasticizers, stabilizers (usually diphenylamine), phlegmatizers, flash eliminators and other additives well known to those skilled in the art allowed creation of a wide spectrum of granulated NC powder. Powder is usually subdivided into pyroxylin, ballistite and cordite depending on the degree of nitration of cellulose and types of plasticizers. (See Горст А.Г. Пороха и взрывчатые вещества. — Москва: «Машиностроение», 1972, с.146-165 и, особенно, с.147-148 -Gorst A. G. "Porokha i Vzryvchatyje Veshchestva". Moscow, Mashinostroyeniye Publishing House p. 146-165, and particularly p. 147-148).

**[0015]** Thus, pyroxylin powder is produced of NC containing as a rule more than 12% nitrogen, plasticized with light solvents; ballistite is produced of colloxylin containing usually somewhat less than 12% nitrogen by weight, plasticized with heavy or fixed solvents; and cordite is produced of both pyroxylin and colloxylin with the usage of combined plasticizers.

**[0016]** However, bulk weight of granulated loose NC gunpowder commonly used for charging ammunition for guns lies in the range of 0.6 to 0.9 g/cm$^3$. For this reason (as the volume of a unitary cartridge case is limited) it is usually impossible:

**[0017]** firstly, to provide for such power intensity of propellant charges that under given values of enclosed volume of the barrel bore, maximum pressure of powder gases in the barrel and the projectile mass or required velocity of the projectile in the moment of the escape from said bore, allows the highest value of ballistic efficiency for a specific gun to be closely attained, and

**[0018]** secondly, to manipulate density and (with a given limited volume) mass of the propellant charge in the wide scope.

**[0019]** The traditional way of reducing said disadvantages is based on utilization of consolidated charges. They are produced by pressing granulated NC powder into pellets or briquettes of which propellant charges of required mass are then assembled. Usually they include one pellet or one briquette, however sometimes they may comprise a plurality of such "elements" having same or differing geometric shape and/or size.

**[0020]** The attempts of inventors are usually directed to the search of such geometric shapes of pellets or briquettes that, on their opinion, must consider the features of equipment and utilization of ammunition for specific types of guns.

[0021] Known in the art is a propellant charge (FR No. 74 04056 Publication No. 2260769) in the form of a pellet made of plasticized powder. Such pellet may have notches, recesses or through holes as required.

[0022] The usage of pellets facilitates charging the ammunition, and varying the shape of pellets allows governing the kinetics of initiation of burning and combustion of consolidated propellant charges having different mass.

[0023] Known is also a propellant charge (U.S. Pat. No. 3,911,825) pressed of plasticized powder in the form of an axially symmetric briquette (e.g., cylindrical or prismatic) having a recess in the middle portion for placing a primer charge.

[0024] When charging ammunition with at least two such briquettes, the independent initiation of burning of each of them promotes fast combustion of the whole combined propellant charge. However, the usage even of a single briquette of the described type does not exclude detonation of the propellant charge in the cartridge-chamber or adjacent part of the bore in the gun barrel.

[0025] A more recent example is a combined propellant charge. It comprises at least one pressed powder briquette and at least one batch of loose powder (UA 37404 A).

[0026] Such charge widens the scope of adjustment of ballistic characteristics of ammunition for hunting rifles.

[0027] However, consolidated elements of propellant charges or single consolidated charges made of a granulated NC base, as described above referring to specific examples, have only the appearance of solid monoliths with smooth surface. The cut, however, clearly shows the boundaries of individual powder granules inside the charge body. That is why propellant charges pressed of usual powder are disintegrated into parts having unequal sizes and irregular shapes immediately after initiation of burning, which parts further disintegrate into initial powder granules, which may cause instability in burning and detonation of the charge in the cartridge-chamber or adjacent part of the bore in the gun barrel.

[0028] All the attempts to overcome this disadvantage of usual consolidated charges have failed so far according to the available data.

[0029] Even a process for production of NC base for consolidated charges for guns (UA 21749 A), which is the most alike with the method of the invention and is created by the same inventors, includes (though in a simplified flow) preparing granulated stabilized pyroxylin powder and transferring it to the production of consolidated charges. Taking into account generally known methods for production of pyroxylin, this method includes:

[0030] (1) nitrating fine-fiber cellulose stuff till obtaining predetermined concentration of nitrogen in the prepared NC being in the form of wet pulp;

[0031] (2) hot-water rinsing the NC pulp for removal of the remainders of the nitrating mixture and low molecular by-products of nitration;

[0032] (3) grinding the rinsed wet NC pulp to obtain suspended disperse particles in aqueous medium;

[0033] (4) finally rinsing the grinded NC;

[0034] (5) dewatering and cleaning the NC of unintentional mechanical impurities;

[0035] (6) modifying (optionally) the obtained powder by adding suitable stabilizer, particularly diphenylamine, and/or phlegmatizer and/or other agent;

[0036] (7) granulating initial (after step 5) or modified (after step 6) grinded NC to obtain granulated powder as a NC base;

[0037] (8) transferring this base to production of consolidated charges having predetermined mass and shape.

[0038] This method avoids such traditional steps as plasticizing the grinded NC with an alcohol-ester mixture, extruding, pre-curing, cutting the stock to produce granulated powder, finally dry-curing the powder granules, size separating the granules, wetting in water for extraction of remainder of solvent, and finally drying to the predetermined residual moisture.

[0039] However, even simplified transformation of fibrous NC into granulated powder as a base for consolidated charges, which is correspondingly accelerated and demands smaller expenses of material and energy resources, does not lead to appreciable reduction in fire risk and explosion hazard of the production. For this reason, any violation of safety precautions may be harmful for the personnel and surroundings.

[0040] In the aforementioned UA 21749 A, a consolidated propellant charge is disclosed which is the most alike with the charge of the invention, Said consolidated propellant charge is in the form of at least one briquette having a predetermined geometric shape and a mass of 0.2 to 2.0 g. The briquette is pressed of granulated powder obtained by the method described and having average density in the range of 0.75 to 1.2 g/cm$^3$.

[0041] Long-term experiments with such granulated NC based charges have shown that after initiation they not always bum uniformly and quite often disintegrate prematurely turning into gas-powder mixture that can detonate in the cartridge-chamber or adjacent part of the bore in the gun barrel.

## Disclosure of the Invention

[0042] The invention is based on the problem of creation (by way of reduction in number and change in the sequence of steps) still more safe method for production of such non-plasticized NC base that allows pressing consolidated, preferably propellant, charges that constantly retain integrity upon initiation of burning and in the process of burning.

[0043] Said problem is solved in that in the method for production of NC base for consolidated charges which includes:

[0044] nitrating fine-fiber cellulose stuff to obtain predetermined concentration of nitrogen in the prepared NC being in the form of wet pulp;

[0045] removing remainders of the nitrating mixture and low molecular by-products of nitration, unintentional mechanical impurities and excess of moisture from said pulp;

[0046] grinding the NC fibers;

[0047] adding (optionally) at least one modifying agent in the NC stock; and

[0048] transferring the obtained NC base proper or with at least one modifying agent to production of consolidated charges, according to the invention,

[0049] after removing remainders of the nitrating mixture, low molecular by-products of nitration, unintentional mechanical impurities and excess of moisture, said NC pulp is dried to the predetermined residual moisture that is enough to provide for safe grinding;

[0050] dried NC pulp is grinded to obtaining NC base for consolidated charges in the form of polydisperse mixture of fibrous particles; and

[0051] said mixture in its initial form or with at least one modifying agent added is transferred to production of consolidated charges.

[0052] It is clear from the above that comparing to the state of art the method of the invention:

[0053] firstly, is essentially simpler because it allows obtaining NC base for consolidated charges from non-plasticized fibrous stock,

[0054] secondly, essentially more productive, more economical and less dangerous for both the personnel and surroundings due to elimination of the step of plastisizing NC with volatile solvents,

[0055] thirdly, it allows obtaining consolidated, particularly propellant, charges in the form of felt pellets or briquettes having through sponginess that remain integral upon initiation of burning and in the process of burning and are unable to detonate in the cartridge-chamber or adjacent part of the bore in the gun barrel.

[0056] The ability of polydisperse mixture of fibrous particles of non-plasticized NC to form a felt structure under suitable conditions of pressing happened to be our unexpected discovery that can essentially change the organization of production of NC explosives.

[0057] The first additional characteristic feature consists in drying the NC pulp by air blowing through the layer of fibers at the temperature of 50 to 70° C. till residual moisture of not greater than 4% by mass prior to grinding. Such drying is economical and safe.

[0058] The second additional characteristic feature consists in drying the NC pulp till residual moisture in the range of 2 to 4% by mass. This simplifies and accelerates grinding said pulp.

[0059] According to the third characteristic feature, which is additional to the first or second characteristic feature, the NC pulp is dried prior to grinding to residual moisture of not greater than 2% by mass. This essentially simplifies and accelerates, and quite often eliminates finish drying of consolidated charges made of mixture of NC fibers.

[0060] The fourth additional characteristic feature consists in grinding the dried NC pulp to obtain polydisperse mixture of fibrous particles containing at least 95% by mass of particles having a ratio of length L to maximum cross dimension d that meets the condition $L/d \leqq 24$. This mixture provides for a stable structure of the felt type even when producing consolidated charges having the mass of less than 1 g.

[0061] Said problem is solved also in that the consolidated propellant charge in the form of at least one NC based briquette having predetermined geometric shape and mass, according to the invention, is made of a mixture of polydisperse NC fibers and has a spongy felt structure. Such charges are permeable for powder gases after initiation of burning. Therefore they retain integrity while burning, and they are essentially unable to detonate in the cartridge-chamber or adjacent part of the bore in the gun barrel.

[0062] According to the first additional characteristic feature, at least 95% by mass of said mixture are comprised of fibrous particles having a ratio of length L to the maximum cross dimension d that meets the condition $L/d \leqq 24$. Such make-up of the mixture ensures that the felt structure be stable even in the charges having the mass of less than 1.

[0063] According to the second additional characteristic feature, said charge has average density in the range of 0.7 to 1.3 $g/CM_3$. This allows controlling the combustion rate of consolidated charges through all their volume.

[0064] According to the third additional characteristic feature, said charge has residual moisture of not greater than 2% by mass, which provides for stable burning of the charge after initiation with minimum consumption of priming explosive.

[0065] According to the fourth additional characteristic feature, said charge besides of NC base comprises a modifying agent selected from the group consisting of stabilizers, phlegmatizers, flash eliminators, anti-erosive additives, energy additives and arbitrary combination of at least two of said modifying agents. This allows making consolidated charges of various functions.

[0066] According to the fifth additional characteristic feature, said charge sponginess is selected within the range of 5.6 to 57.0% of the whole charge volume, and the six characteristic feature, which is additional to the fifth characteristic feature, consists in that the sponginess is within the range of 19.4 to 57.0% of said volume. Adjustment of sponginess, particularly in said subrange, allows controlling the combustion rate of consolidated charges in the wide scope through all their volume.

[0067] According to the seventh additional characteristic feature, the NC fibrous particles in near-surface layer are immobilized at least in the zone of the side-wall. This prevents loosening of the near-surface layer and possible crumbling of fibrous particles when being shaken, e.g. during transportation of the ammunition, in as greater degree as higher is the mass of propellant charges of the invention.

[0068] According to the eight additional characteristic feature, said fibrous particles are immobilized with the help of a thin NC film, which does not prevent effective combustion of the whole charge.

[0069] And, at last, the ninth additional characteristic feature consists in that said NC film has through pores, which along with increasing mechanical strength of charges provides for free penetration of the igniting impulse deep into the spongy stuff of the charge directly after initiation of burning.

## BRIEF DESCRIPTION OF DRAWINGS

[0070] In the accompanying drawings:

[0071] **FIG. 1** is a photomicrography of $130^{\times}$ enlarged initial (non-grinded) NC pulp base for charges;

[0072] **FIG. 2** is a photomicrography of $130^{\times}$ enlarged grinded NC pulp base for charges;

[0073] **FIG. 3** is a photomicrography of $130^{\times}$ enlarged microscopic section of a NC pulp based consolidated charge of cylindrical shape (in the bottom left window: a picture of the charge showing the plane of the microscopic section);

[0074] **FIG. 4** is a photomicrography of $90^{\times}$ enlarged surface of a break in the charge of Fib. **3** (in the bottom left window: a picture of the charge showing the point of the break);

[0075] **FIG. 5** is a sequence of photographs of $3^{\times}$ enlarged consolidated charges made of NC fibrous particles, namely: (1) an initial charge, (2) a charge extinguished immediately after the initiation of burning, (3) and (4) charges extinguished at intermediate stages of burning, and (5) a charge extinguished at the end of burning;

[0076] **FIG. 6** is a photomicrography of $130^{\times}$ enlarged surface of the partially burnt charge (3) of **FIG. 5**, where the arrows show some deep spit-outs (in the bottom right window: a picture of the partially burnt charge).

## BEST MODE FOR CARRYING OUT THE INVENTION

[0077] The invention is further explained in terms of:

- [0078] general disclosure of the method for production of NC base for consolidated charges and practical recommendations for its realization;
- [0079] description of the method for production of NC based consolidated charges;
- [0080] examples of utilization of said base in consolidated propellant charges, preferably for hunting rifles; and
- [0081] results of comparison tests of novelty and known propellant charges.

[0082] In the general case, the method for production of NC base for consolidated charges includes:

- [0083] (a) nitrating fine-fiber cellulose stuff to obtain predetermined concentration of nitrogen in the prepared nitrocellulose (NC) being in the form of wet pulp;
- [0084] (b) removing remainders of the nitrating mixture and low molecular by-products of nitration, unintentional mechanical impurities and excess of moisture from said pulp;
- [0085] (c) drying the cleaned and partially dewatered pulp to residual moisture that is enough to provide for safe grinding of NC fibers;
- [0086] (d) grinding the dried NC pulp (see **FIG. 1**) to provide NC base for consolidated charges in the form of loose polydisperse mixture of rather crimped fibrous particles (see **FIG.2**;
- [0087] (e) adding (optionally) at least one modifying agent in said NC base; and
- [0088] (f) transferring said NC base proper or with at least one modifying agent to production of consolidated charges.

[0089] These steps are generally carried out in the following way.

[0090] In step (a), cotton, carefully cleaned of mechanical impurities, is usually taken as fine-fiber cellulose stuff. Though, it is cleat for those skilled in the art that in the situation of sharp demand for raw materials a high quality wood cellulose in the initial form and even in the form of high quality loose paper can be utilized instead of cotton.

[0091] Nitrogen concentration in dry NC pulp can be of 11.0 to 14.1% for NC base for all sorts of charges, preferably 11.5 to 12.0% for colloxylin, 13.0 to 13.5% for pyroxylin No. 1, and 12.05 to 12.4% for pyroxylin No. 2. The nitration is carried out till obtaining such concentration of nitrogen in NC that is selected within a required range. It is practical to obtain NC having various nitrogen concentration for future mixing in the production of charges having various ballistic properties.

[0092] The nitration is carried out with usage of compositions of nitrating mixtures, liquor ratios, temperatures and times well know to those skilled in the art. Thus, initial nitrating mixtures usually contain 20.5 to 21.5% nitric acid and 63.0 to 68.9% sulfuric acid, and not more than 16.5% water. Liquor ratio, i.e. ratio of the mass of acidic nitrating mixture to the mass of cellulose is selected within the range of 45 to 50 for cotton and of 33 to 38 for wood cellulose. The temperature is usually taken within the range of 25 to 30° C. when obtaining pyroxylin having nitrogen concentration of more than 13% by mass in dry product, and within the range of 35 to 40° C. when obtaining pyroxylin and colloxylin having nitrogen concentration of 12 to 13% by mass.

[0093] In step (b), standard equipment of the type of rinsing apparatus, spinners and magnetic separators as well as known parameters for multiple hot rinsing with decoction of the pulp, its squeezing till residual moisture of not greater than 32% and cleaning of probable mechanical impurities are generally used.

[0094] In step (c), NC pulp is usually dried by blowing air at temperature within the range of 50 to 70° C. through a layer of fibers placed on porous, e.g. canvas backing. The velocity of blowing must be such as to exclude entrainment of dried fibrous particles by the air flow. Drying is stopped when residual moisture of not greater than 4% is obtained, preferably within the range of 2 to 4% and the most preferably not greater than 2% by mass.

[0095] In step (d), the dried NC pulp is grinded, as a rule by rubbing through a mesh with maximum aperture diameter of not greater than 2 mm up till obtaining a polydisperse loose mixture of fibrous particles. It is preferential that at least 95% by mass of this mixture constitute particles having a ratio of length L to maximum cross dimension d corresponding to the condition L/d<24. This condition is met by such mixture of grinded NC fibers wherein elemental fibers have diameter approaching the mean value of 0.05 mm and length having mean value of not greater than 1.2 mm.

[0096] The degree of grinding can be checked by analyzing samples under microscope. However, it is more practical to use "sedimentation test". A sample of dry grinded NC fibers having the mass of 10 g is placed into a standard cylindrical 500 ml measuring jar having the inner diameter of about 47 mm and the scale points in milliliters on a side wall. 250 ml of distilled water is poured over the sample, which is thoroughly stirred up. The obtained suspension is left for one hour under the room temperature, and the interface between water and sediment is then determined on the scale. Such interface is usually found at the level of 85-90 ml for the sediment of non-grinded NC pulp and not greater than 62 ml for the sediment of fibers that meets the condition L/d<24.

[0097] In step (e), which is carried out when additional requirements are applied to charges, at least one modifying agent taken in suitable amount can be introduced into the NC base, said modifying agent being selected from the group consisting of:

[0098] stabilizers (usually diphenylamine Of derivatives of urea wherein hydrogen atoms are substituted only by ethyl or methyl and ethyl groups),

[0099] phlegmatizers (camphor as a rule),

[0100] flash eliminators (usually potassium salts),

[0101] anti-erosive additives (usually titanium dioxide, red lead, dinitrotoluene, dibutyl phthalate, or their arbitrary combinations),

[0102] energy additives (of the type of hexogen, octogen or their combinations) and arbitrary combination of at least two of said modifying agents.

[0103] When a modifying agent is introduced in the form of a solution, the NC base is transferred to production of charges after finish drying (preferably under a light air flow having the temperature of about 30° C. up till residual content of volatile solvents of not greater than 6%, preferably not greater than 5% by mass). This is done, for example, after addition of diphenylamine or camphor in alcohol solution or potassium salt in water solution. There is no need in finish drying after introduction of dry fine-dispersed anti-erosive additives.

[0104] In step (f), NC base is usually hermetically packed for long-term storage and/or transportation, or transferred directly to charge production. Prior to this step, residual moisture of said base can be determined by any suitable way, e.g. by careful drying in vacuum till achieving a constant mass, and the obtained data can be placed on the package or included in the accompanying papers.

[0105] Then the actual value of residual moisture must be used when preparing the NC base to processing in consolidated charges. It is especially important to take this parameter into account when calculating doses for such base to provide for the required mass of charges and for evaluation of necessity in their finish drying after pressing.

[0106] If the manufacturer of a non-plasticized NC pulp base failed to indicate its residual moisture, the manufacturer of charges shall determine this parameter prior to dosing said base.

[0107] Before making non-standard charges or ammunition, ballisticians determine specific values of mass, size, shape and density of charges and permitted deviations from such values, using well known methods, depending on specific application and required power of ammunition and allowable size and shape of consolidated charges. It is clear that results of such calculations are usually corrected after firing tests of a specimen batch of ammunition.

[0108] Multicavity molds are used, as a rule, for production of consolidated charges utilizing said base Here, independently of the number of cavities, molds are generally equipped with dies having through holes, pairs of plungers for each hole designed for opposing motion and limit stops for plungers. Such limit stops essentially eliminate overpressing consolidated charges and provide for stability of their longitudinal size.

[0109] The volume of cavities for forming is determined taking into consideration the bulk weight, residual moisture and size of doses of NC base, and residual clearance between plungers upon termination of pressing is determined taking into account the mass and density of charges predetermined by ballisticians.

[0110] Plungers and holes in dies usually have round cross-sections. However, other shapes of cross-sections (both having axial symmetry and asymmetrical) are not excluded, which shapes can be selected by designers of ammunition, as required, depending on specific application of guns.

[0111] For safe pressing consolidated charges the mean velocity $V_{mp}$ (mm/s) of approaching plungers having gage $d_p$ usually meets the condition $V_{mp} \leqq 10^4/d_p^2$.

[0112] The workers in the art will understand that for plungers having round cross-section the gage $d_p$ is equal to diameter, and for other shapes of plungers the gage is determined on the principle of hydraulic analogy with corresponding round plungers.

[0113] It is also clear, that directly after putting doses of non-plasticized NC pulp base weighed or measured by volume in the mold cavities, the velocity of plunger approach can be equal or at least close to the maximum design rating, and then this velocity is usually reduced. This deceleration of plunger approach, as the charges are being pressed, must be as more noticeable as greater is the mass and longitudinal size of the charge being pressed.

[0114] Depending on residual moisture of the utilized NC base the ready charges are either finish dried or transferred directly for packing in sealed packages for transportation and/or storage or for charging ammunition.

[0115] Finished charges (see **FIG. 3**) have spongy structure of the felt type, which appears in the result of twisting of crimped elementary fibers (see **FIG. 4**). Felting takes place as much reliable as great is proportion of particles having a ratio of length L to the maximum cross dimension d that meets the condition L/d≦24 in the polydisperse mixture of NC fibers. Therefore, it is highly advisable that this proportion be not less than 95% by mass.

[0116] It is advisable that the mean density of finished consolidated charges be not smaller than 0.7 g/cm$^3$, for when having a smaller density, they can crumble prior to being charged in ammunition, and not greater than 1.3 g/, for when having a greater density, burning of NC "felt" can be unstable after initiation. However, these limits are preferable but not binding. Actually:

[0117] when strictly following the above condition L/d≦24, the felt structure can be obtained even with density of finished consolidated charges somewhat smaller than 0.7 g/cm$^3$, which is acceptable when making friable propellant charges for large-caliber hunting rifles or erection guns and perforators, and

[0118] density of small mass (about 0.2 g) charges (preserving through pores required for stable burning across the whole volume) can be close to the ultimate achievable value of 1.56 g/cm$^3$ when pressing.

[0119] The actual density of charges can be determined by weighing, calculating the volume by means of standard mathematical formulations (after measuring linear dimensions with the help of appropriate means) and dividing the mass by the volume.

[0120] It should be noted that in cases when propellant charges being part of charged ammunition are subject to long-term storage and/or transportation, it is expedient that NC fibrous particles in near-surface layer be immobilized at least in the zone of the side-wall. A thin NC film, which can have through pores, is enough for this purpose.

[0121] Such film is easy to apply, e.g. by means of spraying a solution of NC in suitable volatile solvent, particularly in acetone, or spraying such solvent over the surface of a pressed propellant charge, which leads to partial dilution of nitrocellulose. Both in the former and the latter options, the fibrous particles in near-surface layer stick together and after short-time finish drying form a film strong enough to preserve friable charges from crumbling and impairing their ballistic characteristics.

[0122] For stable burning after initiation with minimum consumption of the priming explosive, it is advisable that residual moisture of the finished charges be not greater than 2% by mass.

[0123] Naturally, the finished charge besides of NC base can comprise a modifying agent selected from the group described in detail above which consists of stabilizers, phlegmatizers, flash eliminators, anti-erosive additives, energy additives and arbitrary combination of at least two of said modifying agents. Known to ballisticians rules used for modification of available granular powder can be utilized for choosing specific modifying agents.

[0124] The allowable range of porosity for the finished charges is within 5.6 to 57.0% of their total volume, however, the porosity must preferably be within the range of 19.4 to 57.0% of their total volume.

[0125] It should be kept in mind that actual values of porosity can be determined by the methods known to those skilled in the art, taking into account:

[0126] nitrogen concentration in dry nitrocellulose,

[0127] residual content of moisture in NC fibers,

[0128] density and concentration of involved modifying agents (of which only diphenylamine is usually employed in propellant charges having a shelf life longer than one year) and

[0129] actual density of consolidated charges.

[0130] Minimum porosity of 5.6% applies to consolidated charges made by pressing "up to the stop" clean dry nitrocellulose containing 11% by mass nitrogen. For similar charges of nitrocellulose containing 14% by mass nitrogen, the minimum porosity is 6.5%.

[0131] Maximum porosity of 57.0% applies to consolidated charges made by pressing dry nitrocellulose having nitrogen concentration of 14.1% by mass to actual density of 0.7 g/cm$^3$.

[0132] The disclosed consolidated charges, designated NL hereafter, can be utilized for charging ammunition both per se and in combination with common loose powder. The finished charges can include both single consolidated parts having the same shape, size and density, and a plurality of such parts having the same or different shape, size and density. Combined propellant charges allow governing in wide range such ballistic parameters as maximum pressure of powder gases in the barrel bore of a gun and muzzle velocity of the projectile, thus affecting the efficiency of a shot.

[0133] These features are illustrated by examples of tests of various charges for smooth-hunting rifle of caliber # 12 (see Table 1 wherein data on pressure in the barrel bore in 'MPa' are calculated on the basis of data in 'Psi' with experimental factor ≅0.115 determined with the help of crusher apparatus).

TABLE 1

Examples of usage of non-plasticized NC pulp base in propellant charges for hunting rifle of caliber # 12

| Examples | Total charge mass, g | Loose part mass, g | Characteristics of NC pulp based part of the charge: Base type | Mass, g | Density, g/cm$^3$ | Number, pcs | Ballistic parameters: Pressure, MPa/Psi | Velocity, (m/s)/fps |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1 | 1.3 | 0 | NL 16.5 | 1.3 | 0.7 | 1 | 60.3/523 | 386/1267 |

TABLE 1-continued

Examples of usage of non-plasticized NC pulp base in propellant charges for hunting rifle of caliber # 12

| | Total | Loose | Characteristics of NC pulp based part of the charge | | | | Ballistic parameters | |
|---|---|---|---|---|---|---|---|---|
| Examples | charge mass, g | part mass, g | Base type | Mass, g | Density, g/cm$^3$ | Number, pcs | Pressure, MPa/Psi | Velocity, (m/s)/fps |
| 2 | 1.3 | 0 | NL 16.5 | 1.3 | 0.9 | 1 | 45.8/397 | 353/1158 |
| 3 | 1.3 | 0.4 | NL 16.5 | 0.5 | 0.9 | 1 | 33.6/291 | 340/1117 |
| | | | NL 16.5 | 0.2 | 1.1 | 1 | | |
| | | | NL 16.5 | 0.2 | 1.3 | 1 | | |
| 4 | 1.4 | 0 | NL 16.5 | 1.4 | 0.7 | 1 | 81.6/707 | 461/1512 |
| 5 | 1.4 | 1.2 | NL 8.0 | 0.2 | 1.2 | 1 | 29.8/258 | 354/1163 |
| 6 | 1.4 | 1.0 | NL 8.0 | 0.2 | 1.1 | 1 | 37.3/323 | 358/1175 |
| | | | NL 8.0 | 0.2 | 1.3 | 1 | | |
| 7 | 1.4 | 0.2 | NL 8.0 | 0.4 | 0.7 | 1 | 93.8/813 | 423/1389 |
| | | | NL 8.0 | 0.4 | 1.0 | 1 | | |
| | | | NL 8.0 | 0.4 | 1.3 | 1 | | |
| 8 | 1.4 | 1.4 | Non | 0 | — | 0 | 37.8/328 | 341/1118 |

**[0134]** The parts of propellant charges marked with the legend NL in Table 1 having diameter 16.5 mm and 8.0 mm were produced of pyroxylin NC pulp base having nitrogen concentration 12.8%, diphenylamine concentration about 1% and total residual concentration of volatile ingredients (water and ethanol used when introducing diphenylamine) up to 1.9% by mass.

**[0135]** Cartridges were charged on standard equipment utilizing plastic cases provided with percussion caps and wads by Winchester Company, lead shot # 3 having diameter 3.5 mm and mass 28.5 g per cartridge and standard smokeless gunpowder for Winchester hunting guns. Charged cartridges were closed up in the way of an eight-point star.

**[0136]** Shown in Table 1 (and cited below) ballistic parameters were determined with the help of a commercially available unit Personal Ballistics Lab OEHLER Model 43 comprising:

- **[0137]** a device for rigidly fixing a gun employed in the experiment;
- **[0138]** at least one strain gage transducer to be rigidly fixed on the outside of the barrel in the zone of the gun cartridge-chamber, which is designed for connection to the program calculation unit for determining the pressure of powder gases in the barrel bore;
- **[0139]** usually three optical, sensors of the type "sky screen" sequentially mounted in one line behind the muzzle of the gun at fixed intervals one from another and also designed to be connected to the program calculation unit for determining the muzzle velocity of projectiles;
- **[0140]** a printer for printing individual test record sheets for each shot and statistical treatment of results of shot runs (usually up to 10).

**[0141]** Table 1 shows the averaging results of fire tests for runs of 10 shots. It is seen from the Table 1:

**[0142]** all the arrangement options for propellant charges incorporating NL parts are operable and

- **[0143]** achievement of the muzzle velocity of lead shot equal with usual ammunition is possible with essentially smaller value of maximum gas pressure in the barrel (example 3 as compared to example 8), or vice versa, some increase in the muzzle velocity of lead shot is observed at the same pressure as in standard option (example 6 as compared to example 8).

**[0144]** Besides, the given examples show that usage of NL parts is useful with relation to ballistic efficiency in production of shotgun cartridges for hunting, sporting and heavy-duty (Magnum) applications. The experience shows that the higher is allowable level of gas pressure in the barrel bore the easier is to achieve an increase in the muzzle velocity of the projectile with the help of NL parts in comparison with usual ammunition. Therefore, for practical application of NL parts the most promising generally are sporting and heavy-duty (Magnum) variants of smooth-bore ammunition and sporting and hunting ammunition for rifled guns.

**[0145]** The above has been proved by the data obtained in firing tests of "Hunter", "Sport" and "Magnum" type 12/70 mm cartridges loaded with shot (32 g mass) and propellant charges of NL type in comparison to the reference data for similar ammunition by world leading companies (see Table 2).

TABLE 2

Comparative data on ballistic efficiency

| Producer, brand and application of ammunition | | Pressure, MPa | Velocity, m/s |
|---|---|---|---|
| Dynamite Nobel, Rottweil (RWS) | | ≦72.6 | $V_{2.5} = 400$ |
| Remington | RTL 12L "Premier" | ≦72.6 | $V_{3\ ft} = 349$ |
| | PR 12S MAG "Premier Magnum" | ≦103.0 | $V_{3\ ft} = 384$ |
| NL Magnum | | 88.3 | $V_{3\ ft} = 469$ |
| NL Sport | | 67.2 | $V_{3\ ft} = 454$ |
| NL Hunter | | 51.4 | $V_{3\ ft} = 385$ |

**[0146]** It will be understood by those skilled in the art that the described embodiments of the invention in no way exhaust resources of other applications of the inventive concept within the scope of the appended claims.

[0147] Thus, it is evident that polydisperse mixture of NC fibrous particles can serve as a "felt" base not only for consolidated propellant charges for any given gun but also as similar base for consolidated signaling charges and pyrotechnic articles that are usually made with the usage of classic black and/or brown powder. It is also obvious that geometric shapes, sizes and masses of consolidated propellant charges for various guns can be essentially different from those shapes, sizes and masses that are pointed out in the specific examples given above and the knowledge of an average worker in the art of ballistics is enough to design and fabricate such charges.

## INDUSTRIAL APPLICABILITY

[0148] The invention is easy to apply in industry as far as it can be implemented on existing enterprises for production of NC explosives obtaining such consolidated charges of optional mass and shape that have spongy felt structure and in principle can not detonate in the cartridge-chamber or adjacent part of the bore in the gun barrel. Actually, **FIGS. 5 and 6** clearly show that consolidated charges of the invention can essentially uniformly bum from all the sides and combust without disintegration into pieces.

What is claimed is:

**1**. Method for production of nitrocellulose base for consolidated charges which includes:

(a) nitrating fine-fiber cellulose stuff to obtain predetermined concentration of nitrogen in the prepared nitrocellulose being in the form of wet pulp;

(b) removing remainders of the nitrating mixture and low molecular by-products of nitration, unintentional mechanical impurities and excess of moisture from said nitrocellulose pulp;

drying the cleaned and partially dewatered pulp to residual moisture that is enough to provide for safe grinding of nitrocellulose fibers;

(d) grinding the dried nitrocellulose pulp to provide nitrocellulose base for consolidated charges in the form of polydisperse mixture of fibrous particles;

(e) adding (optionally) at least one modifying agent in said nitrocellulose base; and

(f) transferring said nitrocellulose base proper or with at least one modifying agent to production of consolidated charges.

**2**. The method of claim 1 in which prior to grinding the nitrocellulose pulp is dried by air blowing through a layer of fibers at the temperature of 50 to 70° C. till residual moisture of not greater than 4% by mass prior to grinding.

**3**. The method of claim 2 in which prior to grinding the nitrocellulose pulp is dried till residual moisture within the range of 2 to 4% by mass.

**4**. The method of claim 2 in which prior to grinding the nitrocellulose pulp is dried till residual moisture of not greater than 2% by mass.

**5**. The method of claim in which the dried nitrocellulose pulp is grinded to obtain polydisperse mixture of fibrous particles containing at least 95% by mass of particles having a ratio of the length L to the maximum cross dimension d that meets the condition $L/d \leqq 24$.

**6**. A nitrocellulose based consolidated propellant charge in the form of at least one briquette having predetermined geometric shape and mass, that it is made of a mixture of polydisperse nitrocellulose fibers and has a spongy felt structure.

**7**. The charge of claim 6 in which at least 95% by mass are comprised of fibrous particles having a ratio of the length L to the maximum cross dimension d that meets the condition $L/d \leqq 24$.

**8**. The charge of claim 6 which has average density within the range of 0.7 to 1.3 g/cm$^3$.

**9**. The charge of claim 6 which has residual moisture of not greater than 2% by mass.

**10**. The charge of claim 6 which besides of nitrocellulose base comprises a modifying agent selected from the group consisting of stabilizers, phlegmatizers, flash eliminators, anti-erosive additives, energy additives and an arbitrary combination of at least two of said modifying agents.

**11**. The charge of claim 6 which has sponginess within the range of 5.6 to 57.0% of the total volume.

**12**. The charge of claim 11 which has sponginess within the range of 19.4 to 57.0% of the total volume.

**13**. The charge of claim 11 in which fibrous particles of nitrocellulose in the near-surface layer are immobilized at least in the zone of the side-wall.

**14**. The charge of claim 13 in which said fibrous particles are immobilized with the help of a thin nitrocellulose film.

**15**. The charge of claim 14 in which said nitrocellulose film has through pores.

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