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MANUFACTURE OF PROPELLENT EXPLOSIVES

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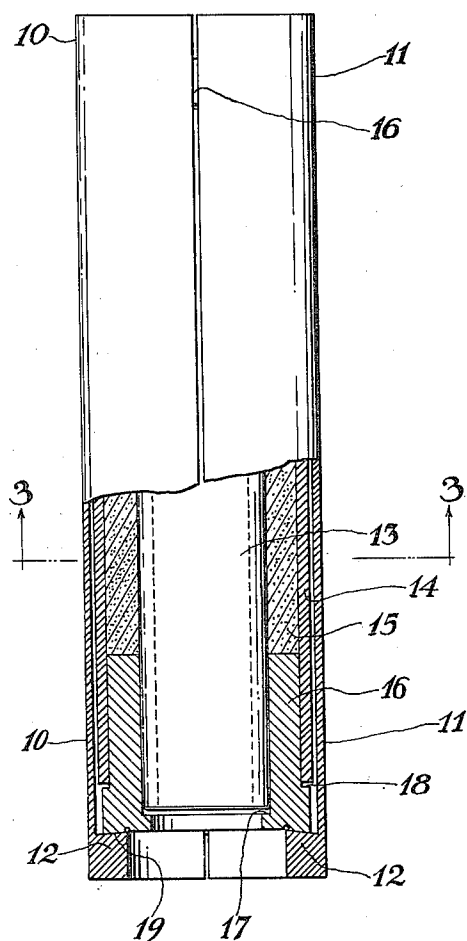


Fig. 1

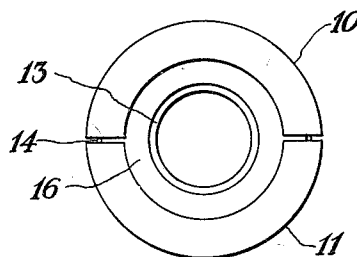


Fig. 2

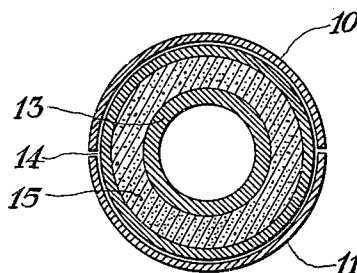


Fig. 3

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MANUFACTURE OF PROPELLENT
EXPLOSIVESCharles Earnest Silk and George C. Dintelmann,
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This invention relates to the manufacture of propellant explosives, and more particularly to the improved production of giant grains of propellant.

For certain uses, as in the propellant for heavy rocket projectiles, the principal requirements called for in the charge, a high concentration of energy and, at the same time, a relatively slow burning rate, are met by the use of very large grains, for example, three to six inches in diameter and four to twelve inches long, of gelatinized nitrocellulose-nitroglycerine composition. The required slow rate of burning is obtained largely by reason of the very thick web; however, the grains must be sufficiently homogeneous and coherent in structure that the combustion proceeds evenly throughout the grains without the sudden production of extremely high pressures such as would result upon fragmentation of the grains during the combustion.

In view of the practical impossibility of removing volatile solvent from giant grains to the desired extent, the methods ordinarily used in the manufacture of propellant grains for small arms and ordnance, which involve the extrusion or other means of shaping nitrocellulose in admixture with a volatile solvent, are not applicable for this purpose.

Heretofore, the manufacture of extremely large grains has generally involved the extrusion by means of giant presses of the composition which had previously been prepared in gelatinized sheet form. The production of such sheets has required a series of rolling operations, removal of volatile matter being accomplished during the final rolling steps or by a subsequent drying treatment. Gelatinization was effected by the rolling, frequently supplemented by intermediate kneading operations carried out in the presence of a volatile solvent for the composition.

In addition to the difficulties involved in carrying out the foregoing complex series of preliminary operations, the extrusion step has been disadvantageous in its requirement for expensive equipment, huge presses being necessary for the production of the extremely high pressures required for expressing the highly viscous mass through a suitable die. Furthermore, the operation is, at best, very slow and requires the observance of many precautions to avoid explosion during the extrusion. Also, the extensive rolling leads to loss of nitroglycerine by volatilization, and may lead to undesirable variations in the composition of the mixture at the extrusion stage.

The present invention has as an object the

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provision of a greatly simplified and improved procedure for the manufacture of suitable giant propellant grains of gelatinized nitrocellulose-nitroglycerine composition, whereby the disadvantages of prior procedures are overcome.

A further object is to provide a process of this type which involves neither the difficult final extrusion step nor the complex series of rolling operations which have heretofore been required.

As another object, this invention aims to provide a method enabling the production of giant propellant grains by a molding procedure, wherein gelatinized nitrocellulose-nitroglycerine pellets are surface plasticized to render them suitable for consolidation.

A further object is the provision of an improved method for accomplishing the consolidation of a plurality of such pellets to produce desirable giant grains of propellant.

Other objects will be apparent from the following detail description.

In the drawings, Fig. 1 represents a side view, partly in section, of a mold assembly which may advantageously be employed in the practice of this invention. Fig. 2 is an end view of the assembly, and Fig. 3 is a section taken along line 3—3 of Fig. 1.

The foregoing objects are accomplished in accordance with the present invention, generally stated, by providing pellets of gelatinized nitrocellulose-nitroglycerine composition, furnishing the pellets with a tacky surface coating by the admixture of a suitable plasticizer ingredient, and then consolidating the pellets in a mold while under adequate conditions of temperature and pressure to produce desirable giant propellant grains.

It will be observed that by this procedure a substantially homogeneous grain is formed by the coalescence of intermediate pellets previously rendered non-uniform in composition by the provision of a plasticized surface film; this has been found essential for the ready attainment of a properly molded grain displaying a strongly coherent structure. The attempted consolidation of unplasticized nitrocellulose-nitroglycerine pellets under heat and pressure has been found to result in dangerous exudation of nitroglycerine, while the use of pellets in which the plasticizer ingredient is uniformly incorporated is not conducive to thorough coalescence and strong bonding.

Furthermore, it has been found that the plasticizer should preferably be a deterrent substance capable, when mixed with the pellets, of forming

an adherent surface film which is retentive of nitroglycerine therein, so that no harmful exudation occurs under pressure during the grain-forming step.

The plasticizer ingredient, although forming but a small proportion of the composition, thus accomplishes a number of essential functions such as promoting the coalescence of the pellets, preventing the exudation of nitroglycerine, and providing the desired plasticity and combustion characteristics in the final grain. By initially concentrating the plasticizer at the surface of the pellets, full advantage is taken of the limited quantity in fulfilling the first two above-named functions, and at the same time, the danger of handling and pressing the composition is materially reduced. Substantial homogeneity of the composition is however attained during the subsequent grain-forming operation.

When the starting material consists of fibrous nitrocellulose, the pellets are desirably formed in the presence of water, for example, by a process involving agitating the nitrocellulose and a water-immiscible solvent therefor in water suspension and heating. The pellets may then be impregnated with nitroglycerine by a process of surface-treatment in water suspension. The gelatinized nitrocellulose-nitroglycerine pellets are then substantially freed of volatile matter by a suitable drying treatment. Screening may be employed either before or after the drying step in order to provide pellets of the most desirable size, for example, such that practically all the material will pass through a screen having openings of about 0.05 inch and be retained on a screen having about 0.005 inch openings.

The dried pellets are then briefly mixed with a small amount of non-volatile plasticizer, the mixing being limited to a period which provides uniform distribution of this ingredient as a tacky surface film over the granules.

The required amount of coated pellets is then placed in a suitable mold, and is confined therein under adequate conditions of pressure and temperature for a sufficient period to produce a coalesced grain. After cooling, the completed grain is removed from the mold.

While the advantages of the foregoing procedure are not limited to any specific compositions, particularly favorable results are obtainable in producing dense giant grains comprised essentially of 35-65% gelatinized nitrocellulose, 25-50% nitroglycerine, and 2½-20% plasticizer.

For greatest effectiveness, the nitrocellulose should have an average nitrogen content greater than 13% and may desirably consist of a suitable blend of several types of nitrocellulose, such as of pyrocotton and guncotton, containing respectively about 12.6% and 13.4% nitrogen. Pyroxlin containing about 11.8% nitrogen may be used in the composition. If desired, the nitrocellulose content may consist entirely of pyrocotton or of guncotton, the latter particularly when a grain of maximum potential is sought. An outstanding advantage of this invention is that it enables the production of giant grains of high potential compositions, which are particularly difficult to extrude. Up to about 15% of the nitrocellulose may be advantageously replaced by trinitrotoluene, since the physical properties may be enhanced thereby without lowering the potential of the resulting grain.

Nitroglycerine in the composition may be supplemented by other nitrated polyhydric alcohols,

for example, ethylene glycol dinitrate or diethylene glycol dinitrate.

While various known plasticizers for nitrocellulose may be employed, dialkyldiphenylureas have been found to display outstanding qualities for use in accordance with this invention. The desired surface coating is readily formed after brief mixing, no difficulty is encountered during the pressing operation, and the resulting product is a firmly coherent grain having excellent physical properties and combustion characteristics. The advantages are particularly evident in grains of high nitroglycerine content in which the substituted urea plasticizers yield more firmly coherent grains than ester plasticizers such as dibutyl phthalate, alkyl phthalyl glycolates, ethyl sebacate, and tri-aryl phosphates.

It is desirable that solid plasticizers be added to the pellets as a powder, for example, such as to pass through screen openings of about 0.010 inch. A mixed plasticizer is conveniently prepared by powdering and screening the solidified composition obtained after cooling the molten mixture.

In one embodiment illustrating this invention, giant grains having the composition:

	Per cent by weight
Nitrocellulose (13.2% nitrogen)-----	45
Trinitrotoluene-----	10
Nitroglycerine-----	40
Diethyldiphenylurea-----	5

may be prepared in accordance with the following procedure.

Fibrous nitrocellulose consisting of a blend of three parts by weight of pyrocotton and seven parts by weight of guncotton is converted to gelatinized globules, in accordance with U. S. Patent 2,027,114, by agitating the nitrocellulose in water suspension with a solvent such as ethyl acetate, continuing the agitation in the presence of a suitable protective colloid or emulsifying agent in order to form spherical droplets of the nitrocellulose solution, and then hardening the same by distillation of the volatile solvent during continued agitation and heating.

The procedure is desirably carried out so as to result in gelatinized nitrocellulose globules ranging from about .010 to about .040 inch in diameter. Preferably, the removal of volatile solvent is carried out in the presence of a solute in the water phase, as disclosed in U. S. Patent 2,160,626, in order to produce globules having high density, for example, such that the gravimetric density is greater than 0.90.

By virtue of the initial dispersion of the nitrocellulose in the presence of an excess of solvent, the fibrous structure is entirely destroyed; thus, following the removal of solvent, hardened globules are obtained in which the nitrocellulose is uniformly and thoroughly gelatinized.

The trinitrotoluene content may be incorporated in these pellets by dissolving the same in the volatile solvent used for gelatinization, or by adding the solid directly to the aqueous suspension of nitrocellulose and solvent. The addition may likewise be made near the end of the hardening process when the temperature of the suspending bath is above the melting point of the trinitrotoluene, or with the nitroglycerine in the next operation.

The impregnation of the pellets with nitroglycerine is preferably carried out by a process of surface treatment in water suspension. For example, the pellets are suspended in an excess

of water at a temperature of about 65° C., and the nitroglycerine is added thereto dissolved in an equal weight of a composite solvent consisting of about 40% by weight of ethyl acetate and 60% by weight toluene. The addition may be made in several portions, during agitation, each addition being followed by a period of solvent removal, which is facilitated by passing a stream of gas, such as air, nitrogen, or carbon dioxide, through the suspension. A total treatment time of 18 hours under these conditions results in suitable nitroglycerine-impregnated pellets which are substantially free from any volatile solvent.

The moisture content is then reduced to the desired low value by drying the pellets at a suitable temperature for the required period of time, such as, by means of circulated air at 50° C. for a period of 4-5 hours. At this stage, the dried pellets have a gravimetric density of about 0.95 and a content of volatile matter not greater than about 0.5%.

The plasticizer is then uniformly distributed over the pellet surfaces by mixing the powdered material with the pellets for a limited period of time in a kneading machine or other suitable apparatus. The mixing may be accomplished in a period of several hours at ordinary temperatures, or more advantageously in a period of 5-40 minutes at a temperature close to the melting point of the plasticizer. For example, diethyldiphenylurea, or any desired mixture of the same with one or more other plasticizers, may be adequately distributed over the granule surfaces by mixing for two hours at 25° C., or for fifteen to twenty minutes at 65° C. to 70° C., or preferably for five to ten minutes at 25° C. followed by ten to fifteen minutes at 65° C.

The resulting composition is in the form of a tacky mass, in which the individual pellets are provided with an adherent surface coating in which the plasticizer is concentrated, this film, as hereinbefore described, being essential in facilitating the subsequent grain-forming operation.

The required amount of composition is then placed in a suitable mold and is subjected therein to a relatively low pressure which varies according to the temperature of the composition at the time of pressing. In general, the initial pressure will vary from about 200 lbs./sq. in. at about 25° C. to a higher value at a more elevated temperature, for example, 500 lbs./sq. in. at 50° C. With the mold locked to retain substantially the volume obtained at this initial pressure, the assembly is heated to an elevated temperature, below the point at which any appreciable decomposition will occur, and is maintained at this temperature for a sufficient length of time to consolidate the charge into a strongly bonded grain. During the period of temperature rise to the final elevated temperature of treatment, the pressure within the mold gradually increases to a value of three or four thousand pounds per square inch which is effective to produce a coherent and dense structure in the final grain.

A treatment period of 16 hours at 75° C., at a pressure of about 3000 lbs./sq. in., has been found suitable for the fabrication of cylindrical grains having a specific gravity close to 1.60, which weigh about 900 grams and are 4 inches in length, 3.75 inches in diameter, and are provided with a central longitudinal perforation 1.75 inches in diameter. Similar conditions result in excellent cylindrical grains, weighing about 2425 grams, which are close to 12 inches long, 3.75 inches in

diameter, and have a central longitudinal perforation 2 inches in diameter. Following the treatment at the elevated temperature, the locked mold is gradually cooled to ordinary temperatures, i. e. 20-35° C., and the completed grain is then ejected.

While various types of molding equipment may be employed for the consolidation step, particular advantage has been found to reside in the use of detachable self-locking molds, a large number of which may be operated in conjunction with a single press. In the example of a suitable assembly of this type shown in the drawings, an outer locking shell is provided which consists of two half-cylinders 10 and 11, having internally beveled flanges 12 at the ends, the dimensions being such as to enable placing the shell over the mold parts when charged with the proper amount of composition and subjected to a pressure somewhat in excess of the desired initial pressure. On partial release of the pressure, the mold parts become firmly locked together by the shell due to the expansion of the composition. On then being heated to the elevated treating temperature, the pressure which is exerted on the composition rises to the desired operating value due to the fact that the charge has a larger thermal expansion than the mold. The mold proper consists of a pair of coaxial open cylindrical tubes 13 and 14 of one-fourth inch steel, having polished operating surfaces which, for example, may be chromium plated. These tubes are retained in position, so that the intervening annular space forms the desired molding chamber for the charge 15 by a hard non-porous bronze bushing 16 at each end, which is snugly fitted between the tubes and is provided with an internal flange 17 and an external flange 18 to lock the two tubes 13 and 14 in position. The end face of each bushing is outwardly beveled at 19 so as to be engageable by the beveled flanges 12 of the two-piece locking cylinder.

While part 13 may consist of a solid cylinder, the tubular form shown has the advantages of facilitating heat transfer by the passage therethrough of a heating or cooling fluid, as desired.

Following the treatment at the elevated temperature for the required length of time to produce coalescence of the initial pellets, the gradual cooling of the mold and the contents to ordinary temperatures enables the production of giant grains which are substantially strain-free. After the assembly has been cooled to room temperature, the grain is slightly compressed by the application of hydraulic pressure to the closure bushing, permitting the removal of the locking shell. The grain is then ejected from the mold by hydraulic pressure.

Grains of similar composition may be made in accordance with a second example, as follows. Globules of gelatinized nitrocellulose containing 45% nitroglycerine, prepared as described in the first example, are mixed in a suitable kneading machine for forty minutes at 65° C. with the required amount of a mixture of trinitrotoluene with half its weight of a substituted urea composition made up of one to four parts by weight of diethyldiphenylurea and one part by weight of dimethyldiphenylurea. The latter mixture is desirably prepared in powdered form by melting the ingredients together, solidifying by cooling, subdividing, and passing through a screen provided with 0.01 inch openings. The resulting tacky mass is formed into a dense coherent grain

by being subjected to a pressure of 3000 pounds per square inch at 75° C. for 16 hours.

In the third example, the composition of the previous example may be modified in providing nitrocellulose consisting entirely of pyrocotton containing 12.6% nitrogen. Initial pellets may be prepared as in the preceding example and then formed, under a pressure of about 3,000 pounds per square inch at 75° C. for 16 hours, into solid cylindrical grains, 10 inches long and 3¾ inches in diameter, having a specific gravity of 1.59.

In a fourth example illustrating the invention, giant grains containing 55% nitrocellulose, 40% nitroglycerine, and 5% diethyldiphenylurea may be formed by mixing gelatinized nitrocellulose-nitroglycerine globules, prepared as described in the first example, with the plasticizer for 15 minutes at 65° C. The required amount of mixture is then placed in a suitable mold and maintained at a temperature of 65-75° C. under a pressure of about 2000 to 5000 pounds per square inch for a period of four to twenty-four hours, the longer periods being required for the lower temperatures and pressures. By operating at higher temperatures, both the time and pressure may be decreased. For example, excellent grains result in a two-hour molding period at about 90° C. at pressures as low as 250 pounds per square inch.

In a further embodiment of this invention, the preliminary pellets may be formed by a procedure which differs from that described in the previous examples in the use of a smaller quantity of solvent and, if desired, in the elimination of the protective colloid. The resulting pellets, following the solvent removal step, consist of gelatinized nitrocellulose in the form of roughly spherical agglomerates having irregular surface configuration. Such pellets may have a gravimetric density as low as 0.60, which increases to 0.75 or higher, for example, 0.85, following the impregnation with nitroglycerine. This latter treatment and the subsequent steps in the manufacture of the giant grains may be effected essentially as described in the above examples (although the molding period may be shortened), resulting in a product which displays somewhat greater plasticity.

Highly advantageous results can be obtained by providing preliminary nitrocellulose-nitroglycerine pellets consisting of a mixture of globules with the roughly spherical agglomerates made with less solvent. Improved packing and flow of the composition under the conditions of temperature and pressure required for grain formation are apparently secured thereby. The resulting product is a thoroughly coalesced giant grain, displaying a desirable extent of plastic deformation without rupture.

According to another embodiment of the invention, which is of particular advantage when surplus granular gelatinized nitrocellulose of suitable composition is available, the starting material may be formed by subdividing granular gelatinized nitrocellulose to pellets of irregular shape, which for example may pass through a screen having about 0.05 inch openings. These pellets may be impregnated with the explosive ingredients of the composition by a process of surface treatment in water suspension, as hereinbefore described. The subsequent processing steps for the production of giant grains may then be applied as described in the previous examples.

Similarly, the starting material may consist of surplus gelatinized nitrocellulose-nitroglycerine powder grains, of a type intended for use in small

arms ammunition or ordnance, after suitable subdivision and screening, if necessary. The granules may be impregnated with any additional nitroglycerine required in the final composition, preferably by a process of surface treatment in water suspension. The remaining operations may be effected essentially as described above.

It is generally advantageous to provide pellets of gelatinized nitrocellulose-nitroglycerine composition which have a gravimetric density in the dry state greater than about 0.75. Grains having lower density contain an excessive volume of occluded air, the removal of which is necessary for the production of final giant grains having the desired uniform high specific gravity of 1.57 to 1.63. However, low density pellets may be processed in accordance with this invention by evacuating the air from the charge during the application of pressure in the final consolidation step.

From various standpoints, the employment of gelatinized nitrocellulose globules as the initial pellets is accorded the greatest preference. Such pellets are readily and economically manufactured; the nitrocellulose is not only thoroughly gelatinized but also improved in stability during the granulation step; the form lends itself to easy handling throughout the manufacturing procedure and to the easy removal of air on compression; and the high gravimetric density which is obtainable facilitates the production of giant grains of the desired high specific gravity. Furthermore, additional simplification is enabled by the possibility of incorporating the nitroglycerine ingredient in the globules during the granulation step.

The method in accordance with this invention is adapted for fabricating giant grains of various sizes and shapes. A desirable combination of mold pressure, temperature, and time of treatment may readily be evaluated for each particular grain type and composition. In general, a shorter time of treatment or lower pressure or both may be employed as the temperature is increased or as the web of the desired grain is decreased.

Giant grains produced in accordance with this invention have been found highly satisfactory in all respects. The combustion characteristics meet the ballistic requirements, and pressure bomb tests have shown that the grains furnish a smooth development of pressure to the desired maximum.

This desirable behavior depends upon the thorough coalescence of the starting granules into uniformly dense grains having excellent physical properties. The high density which is attained is indicated by the measured values of specific gravity, which range from 1.57 to 1.63. The strength and plasticity have been shown to be in the desired range. For example, sample blocks cut from the grains, have been subjected to pressure and found to rupture at applied pressures ranging from about 1,000 to 7,000 pounds per square inch, after deformation corresponding to 20 to 60% reduction in height.

A qualitative test, consisting in observing the appearance and behavior on bending of a shaving sliced from the grains has also been used to substantiate the successful results. Grains produced in accordance with this invention yield shavings which display good cohesion and flexibility; in contrast, brittle shavings, from which the original particles can be removed, result from molded grains not prepared in accordance

with this invention, for example, from granules not provided with a properly plasticized surface coating.

Advantages of the method of this invention have also been substantiated by noting the effects of hot storage on the grains. For example, storage for 10 days at 55° C. causes the development of fractures, or an appreciable decrease in specific gravity, or of the plasticity and rupture pressure of improperly-made grains, while grains made in accordance with this invention do not develop fractures and display insignificant changes in physical properties.

The thorough coalescence of the granules has also been made evident by microscopic study of thin sections prepared from the grains. With the employment of nitrocellulose globules in the process, the original boundaries are partly discernible as slightly darkened lines and it can be seen that the globules have been distorted by the pressure and welded together into a dense coherent mass.

The comparative experimental data listed in the following tables will make apparent some of the outstanding advantages obtainable in accordance with this invention.

Table I

	No plasticizer	5% plasticizer (this invention)
Exudation of liquid during molding...	Considerable	None
Specific gravity.....	1.63	1.59
Sp. gr., after hot storage.....	1.50	1.59
Rupture pressure, lbs./sq. in.....	750	1,220
Rupture pressure, after hot storage.....	270	1,150
Per cent reduction in height at rupture.....	18.1	37.7
Per cent reduction in height, after hot storage.....	12.3	35.4

The grains tested above were molded for 16 hours at 75° C. and about 3000 pounds per square inch, using the same lot of initial pellets (9.4% TNT, 44.4% nitroglycerine, and balance nitrocellulose), uncoated in one case and in the other coated with dialkyldiphenylurea by mixing for 15 minutes at 65° C. It will be seen that the provision of pellets having a surface film containing plasticizer resulted in a well bonded grain which withstood the hot storage substantially without detriment.

Table II lists measurements made on grains of the same final composition (40% nitroglycerine, 10% trinitrotoluene, 5% dialkyldiphenylurea, and balance nitrocellulose) with the dialkyldiphenylurea incorporated in the initial pellets in one case and coated by mixing with the pellets for 15 minutes at 65° C. in the other, in accordance with this invention.

Table II

	Plasticizer incorporated	Plasticizer coated (this invention)
Exudation of liquid during molding...	Some	None
Specific gravity.....	1.596	1.586
Sp. gr., after hot storage.....	1.478	1.585
Rupture pressure, lbs./sq. in.....	710	1,260
Rupt. press., after hot storage.....	310	1,230
Per cent reduction in height at rupture.....	20.1	36.6
Per cent reduct. in ht. after storage.....	16.8	37.0

Advantages of providing a surface film of plasticizer on the pellets prior to the molding step are apparent from the foregoing comparative data.

It will therefore be apparent that the present

invention provides a desirable advance in the manufacture of giant grains of gelatinized nitrocellulose-nitroglycerine compositions by the elimination of the numerous difficult steps and expensive equipment which have heretofore been necessary.

The extended kneading and repeated rolling operations which were previously required in order to accomplish the desired complete gelatinization of the nitrocellulose component are entirely avoided in accordance with the present invention by providing for the gelatinization of the nitrocellulose initially in the form of preliminary pellets, the dimensions of which are such as to enable the ready elimination of volatile solvent.

The preferred sequence of impregnating the preliminary granules with nitroglycerine followed by brief mixing of the impregnated granules with a suitable plasticizer ingredient results in a mixture which is easily handled for charging in the mold; the resulting concentration of insensitive plasticizer over the surface of the pellets facilitates the subsequent operation for forming the grains.

The accomplishment of the final consolidation by means of detachable self-locking molds not only enables the manufacture of the desired product by means of inexpensive equipment, but also permits a reduction in the number of buildings and manufacturing area required for a given rate of production. This latter factor is due to the greatly increased capacity of the presses, which are ordinarily located in individual barricaded buildings.

It will therefore be apparent that the present invention accomplishes its objects in the manufacture of giant propellant grains of gelatinized nitrocellulose-nitroglycerine compositions. While a number of specific examples have been described in detail, these are to be understood as illustrating the invention and are not to be taken as limiting the scope of the appended claims.

We claim:

1. In the manufacture of propellant explosives, the process comprising providing pellets consisting of a gelatinized nitrocellulose-nitroglycerine composition substantially free of volatile solvent, mixing the said pellets with a non-volatile plasticizer until the exterior of the pellets is rendered tacky without substantial plasticization of the interior of the pellets thereby, and then concurrently heating and compressing a charge of the surface-tacky pellets until consolidated into a substantially homogeneous grain.

2. In the manufacture of propellant explosives, the process comprising providing pellets consisting of a gelatinized nitrocellulose-nitroglycerine composition substantially free of volatile solvent, mixing the said pellets with a dialkyldiphenylurea until the exterior of the pellets is rendered tacky without substantial plasticization of the interior of the pellets thereby, and then concurrently heating and compressing a charge of the surface-tacky pellets until consolidated into a substantially homogeneous grain.

3. In the manufacture of propellant explosives, the process comprising providing pellets consisting of a gelatinized nitrocellulose-nitroglycerine composition substantially free of volatile solvent, mixing the said pellets with a dialkyldiphenylurea until the exterior of the pellets is rendered tacky without substantial plasticization of the interior of the pellets thereby, and then concurrently heat-

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ing and compressing a charge of the surface-tacky pellets at a pressure of 2000 to 5000 pounds per square inch and a temperature of 65° to 75° C. until consolidated into a substantially homogeneous grain.

4. In the manufacture of propellant explosives, the process comprising providing pellets consisting of a gelatinized nitrocellulose-nitroglycerine composition substantially free of volatile solvent, mixing the said pellets with a non-volatile plasticizer until the exterior of the pellets is rendered tacky without substantial plasticization of the interior of the pellets thereby, confining a charge of the surface-tacky pellets at a pressure of the order of several hundred pounds per square inch, then heating said charge while confined to raise the pressure thereon by thermal expansion of the charge, and thereafter maintaining said heat and pressure until the said charge is consolidated into a substantially homogeneous grain.

5. In the manufacture of propellant powder having a grain size of such magnitude that volatile solvent will not readily evaporate from the interior thereof, the process comprising providing gelatinized nitrocellulose-nitroglycerine composition in the form of pellets of a size such that

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volatile solvent can readily be evaporated from the interior thereof, said pellets being substantially free of volatile solvent, mixing the said pellets with a non-volatile plasticizer until the exterior of the pellets is rendered tacky without substantial plasticization of the interior of the pellets thereby, and then concurrently heating and compressing a charge of the surface-tacky pellets until consolidated into a substantially homogeneous grain.

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