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[54] **REINFORCED CONSOLIDATED DOUBLE BASE PROPELLANT**

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Related U.S. Application Data

[62] Division of Ser. No. 354,553, April 24, 1973, Pat. No. 3,860,678.

[52] **U.S. Cl.** **149/14;** 149/2; 149/92; 149/97; 149/98

[51] **Int. Cl.** **C06c 3/10**

[58] **Field of Search** .... 264/3 R, 3 A, 3 B; 149/14, 149/15, 92, 97, 98, 2

[56] **References Cited**

UNITED STATES PATENTS

3,549,436	12/1970	La Rocca	149/15
3,715,414	2/1973	Schultz et al.	264/3 R

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[57] **ABSTRACT**

A method is disclosed for consolidating one or more sheets of double base propellant with a reinforcing mesh to yield a consolidated propellant system.

2 Claims, 2 Drawing Figures

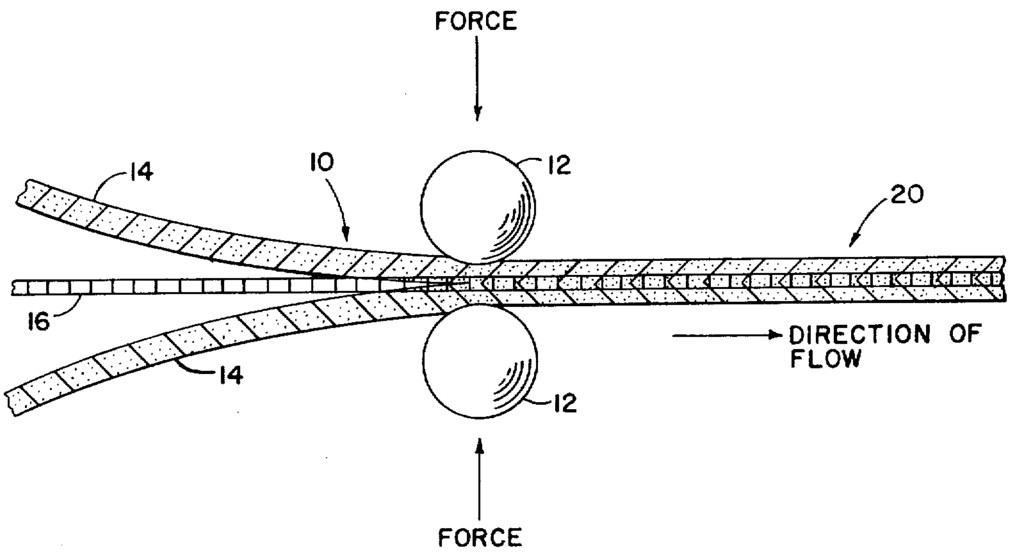
FORCE
14
10
12
20
16
DIRECTION OF FLOW
14
12
FORCE

FIG. 1

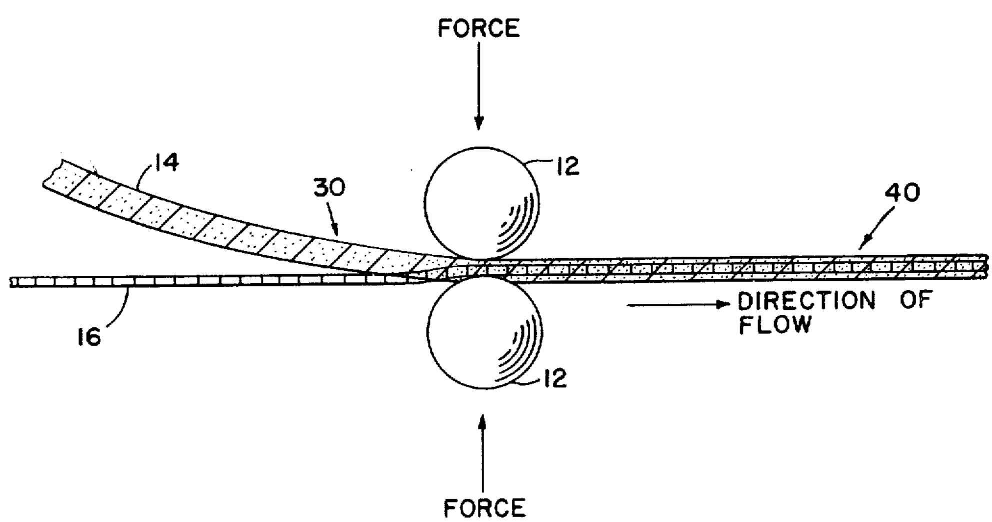
FORCE
14
30
12
40
16
DIRECTION OF FLOW
12
FORCE

FIG. 2

REINFORCED CONSOLIDATED DOUBLE BASE PROPELLANT

CROSS-REFERENCE TO RELATED APPLICATION

This is a division of application Ser. No. 354,553, filed Apr. 24, 1973, now U.S. Pat. No. 3,860,678.

BACKGROUND OF THE INVENTION

The field of this invention is in the double base solid propellant field which relates to the manufacture of propellant useful for recoilless rifles and missile systems.

A burning propellant provides the propulsion force for a projectile or a missile. The propulsion force can be released almost instantaneously to provide propulsion to a projectile or the propulsion force can be released over a longer period of time to provide propulsion for a missile, a rocket, space vehicle, and the like. Propellant can also be used as a source of pressurization for rapid release of gases to operate valves or perform other work functions.

When a propellant is burning it is subjected to forces which tend to cause propellant break up. To withstand these forces, propellant must have sufficient physical properties. The physical properties are imparted by the binder or by added means for reinforcement such as wire, support rods, and the like. In the case of double base propellant the binder is nitrocellulose which is compounded with an energetic plasticizer such as nitroglycerin and additionally contains ballistic additives, processing aids, and stabilizers. The propellant can be cast, rolled into sheet form, or extruded to a pellet form.

Propellants which could be used in an in-tube burning rocket motor have been limited since even the best selected propellants had some undesirable characteristics. For example, the selected propellants which were smokeless and had a good temperature coefficient also had low burning rates. The low burning rates and short burning times would require very thin propellant webs which is generally referred to as the distance (in inches) through which the propellant surfaces recede (normal to surface) before propellant slivers are encountered or the point where the effective thickness of the propellant burns out. The technique of manufacturing very thin web propellant utilizes a rolling procedure which employs steam or hot water heated rollers having variable speeds and having means for adjusting the force which the rollers can exert. In order to utilize the sheets of propellant, a method of loading them into motors and a method of retaining them in the motor while burning time was completed was a requirement which needed to be met. The method to be successful must render the otherwise fragile propellant sheets usable as the propellant system for in-tube burning rocket motors or for the propulsion source for recoilless rifles. The rolled propellant because of the thinness is subjected to being ejected from a burning rocket motor when rapid pressurization occurs which causes propellant breakup. When the propellant is ejected due to malfunction, the rocket motor fails to complete its mission since the source of power is no longer in the rocket motor.

Various techniques have been used for laminating both metallic and nonmetallic materials. Some techniques have used chemical adhesives, such as glues, epoxy compositions and the like. Also, in the nonanalogous art of metal lamination and in the nonanalogous art of plastic lamination, employing both metallic and nonmetallic substrates, rolling to exert pressure to complete lamination has been employed with success. For example, see U.S. Pat. No. 3,719,551 for producing a lead-plastic laminate. However, a laminate of propellant on a solid substrate whether metallic or nonmetallic places additional weight disadvantage for the system wherein used. Also, if a laminate of propellants were prepared using chemical adhesives an additional problem, in addition to the problem of weight addition to the system, could be encountered; i.e., chemical reaction between the propellant and the adhesive. Additionally, propellant laminated to a solid substrate would not have the properties required of a homogeneous consolidated propellant for in-tube rocket motors.

Advantageous would be a method to strengthen propellant without adding the disadvantages of either mechanical lamination or chemical lamination as described. Such a method which could consolidate the propellant with the reinforcing material, if the reinforcing material contributed negligible weight, would be much preferred over a laminated propellant system as will be clearly understood from the descriptive material to follow. Therefore, a propellant system where the reinforcing material and the propellant appear as one consolidated system is the desirable propellant system for use with in-tube rocket propulsion devices.

Therefore, it is an object of this invention to provide a method of consolidating either one or two sheets of double base propellant with a reinforcing mesh to yield a consolidated propellant system of the predetermined thinness for extremely short burning times.

Another object is to produce a consolidated propellant system that has a high structure integrity.

A further object is to provide a consolidated propellant system which can be manufactured into very thin sheets for use in in-tube rocket motors of the short-burning, high-mass type.

SUMMARY OF THE INVENTION

The method of consolidating either one or two sheets of double base propellant with a reinforcing mesh to yield a consolidated propellant system employs variable speed rollers having means for heating and means for varying the force which the rollers exert on sheet propellant and a mesh which are directed between the rollers. A metallic or nonmetallic mesh is positioned between two sheets of sheet propellant which are simultaneously passed between the rollers where the two sheets and mesh are consolidated into one system. The roller speed may be the same or at different speed as dictated by the propellant formulations. The temperature of the rollers may be from ambient to an elevated temperature which best meets the requirements of the individual propellant formulation. The force exerted by the rollers on the propellant is varied to obtain the consolidation and thickness of the finished consolidated system of propellant and reinforcing mesh. The mesh may be of any metallic or nonmetallic material and a mesh of variable size and thickness. Commercially available mesh such as aluminum screen material is appropriate for use in the method of this invention. The propellant sheets may be of any double base propellant formulation and thickness to give the desired propellant ballistics from a consolidated system. However, when one sheet of propellant is consolidated to a mesh, a maximum thickness for the consolidated system is preferred as described below.

When a single sheet of propellant is consolidated with a mesh in accordance with the method of this invention, a thickness of up to about 0.025 inches maximum is preferred for the consolidated system which utilizes a mesh having strand diameters of about 0.010–0.012 inch. Since the propellant is forced through the mesh during the rolling operation, the recommended thickness provides adequate thickness of propellant on each side of the mesh to prevent propellant burn-out on one side which would effect detachment of the propellant from the mesh. The uniformity of propellant distribution through the mesh should be such that propellant burning progresses uniformly after ignition. The heat and pressure used during the rolling operation, the mesh strand diameter, and the thickness of the sheet propellant are variables which effect the thickness of the consolidated propellant.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic drawing of the method of this invention.

FIG. 2 is a diagrammatic drawing of an alternate method of this invention.

rolled type as distinguished from the cast double base propellant. The sheets are cured; however, the sheets will soften when subjected to heat. When subjected to heat and a force such as from heated rollers, the propellant sheets can be forced through the mesh to effect consolidation. It is this property which makes this type propellant desirable for use with the method of this invention which method is for forming a consolidated propellant system comprised of the sheet propellant and a reinforcing mesh.

The reinforcing mesh with strand diameters from about 0.010 to about 0.012 inches is preferred for use where the consolidated propellant system is intended for use in small diameter in-tube burning rocket motors. The small diameter motors in the range of 1¼–2½ inches employ very short-burning, high-mass discharge systems. For larger systems the reinforcing mesh can have larger strand diameters which would be consolidated with thicker sheets of propellants.

The sheets of propellants for consolidation with a reinforcing mesh to form a consolidated propellant system are prepared by standard procedures for formulating, extruding, rolling, and curing which are well known in the art. The propellant composition suitable for use may be any double-base extrudable or rollable type propellant which generally contains the typical ingredients by functions in the weight percents listed as follows:

Ingredient	Function	Weight Percent
Nitrocellulose (12.6%N)	binder	48–50
Nitroglycerin	energetic plasticizer	38–44
Di-n-propyl adipate	crosslinking and plasticizing agent	0.5–7
2-Nitrodiphenylamine	stabilizer	0.5–2.0
Lead beta-resorcylate	ballistic modifier	1.0–2.0
Basic cupric salicylate	catalyst and ballistic modifier	1.0–2.0
Candelilla wax	processing aid	0.1–0.2

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A solid double base propellant which has been rolled to thin sheets (0.017–0.100 inches) is consolidated with a reinforcing mesh by passing the mesh and the sheet propellant between rollers. The rollers exert force and transfer heat to the consolidated system. The rollers are generally operated from ambient temperature to temperatures up to about 212°F. The temperature of the rolling process may be conveniently controlled by hot and cold water which is circulated through the rollers. The rollers are adjustable for the force which they may exert in the consolidation procedure. The consolidated system is comprised of a reinforcing mesh that is consolidated with either one or more sheets of solid double base propellant.

With reference to the drawing, FIG. **1**, there is shown a method **10** of this invention which employs rollers **12** to exert a force and to transfer heat to sheets of solid double base propellant **14** and to a sheet of reinforcing mesh **16** as the propellant and mesh are passed between the rollers to form a consolidated propellant system **20**.

With reference to the drawing, FIG. **2**, there is shown an alternate method **30** of this invention which employs the elements identified in FIG. **1** by like reference numerals for performing the functions described in FIG. **1**, but which forms a consolidated propellant system that is comprised of a reinforcing mesh and a sheet of solid double base propellant.

The solid double base propellant sheets are prepared by rolling a double base composition of the extruded or

The double base propellants known in the trade as M-8, N-12 (HEN-12), N-14, and RDB-4 are all suitable for use in the consolidation method of this invention. The double base propellants contain nitrocellulose and nitroglycerin as their major ingredients plus minor ingredients such as: centralite, vaseline phthalate esters, inorganic salts, and organic compositions which are used for various purposes and functions, in order to ensure stability, reduce flash and/or flame temperature, and improve ignitability. These propellants which fall within the formulation ranges of the ingredients by function and weight percent shown above, have been consolidated in accordance with this invention by rolling metallic and nonmetallic mesh. The propellants have been rolled on one side and two sides of the mesh. The consolidated systems have been test fired, both static and flight, and these firings in recoilless rifles and rocket motors have proven very successful.

Although, the reinforcing mesh may be of any metallic or nonmetallic material and of any mesh and thickness, aluminum mesh offers an additional advantage of contributing additional improvements of increasing the burning rate, maintaining smoother burning, and increasing the specific impulse. Stainless steel and copper mesh have also been employed where higher degree of smokeless exhaust gases are required.

The consolidated propellant system may be loaded in motors by several techniques. The consolidated sheet may be cut in strips after which holes can be punched for slipping on a split ring or sliding on a projecting rod.

The consolidated sheet can also be cut in circular shapes with a hole punched in the center (e.g. wafer shape) so that the circular wafers can be slid on a support rod secured in the tube or case of a rocket motor. The burning time of the rocket motor can be predetermined from the amount of propellant wafers or strips which are loaded in the motor. Burning times as low as 0.005 to 0.010 seconds are obtainable with the consolidated double-base propellant system of this invention.

We claim:

1. A consolidated propellant system comprised of a prior cured double base propellant composition in sheet form that has been softened during a consolidation method whereby said double base propellant composition in sheet form is consolidated with a reinforcing mesh to provide a consolidated propellant system in which said reinforcing mesh has said cured double base propellant composition of uniform thickness on each

side thereof, said cured double base propellant composition consisting essentially of in weight percent nitrocellulose from about 48–50, nitroglycerin 38–44, and the balance being trace amounts of 0.1–2.0 of a cross-linking agent, stabilizer, ballistic modifier, catalyst, and procesing aid to enable said cured double base composition to be consolidated with said reinforcing mesh to provide a uniform thickness of propellant on each side of said reinforcing mesh, and said reinforcing mesh being selected from fiber glass, aluminum, copper, and stainless steel.

2. The consolidated propellant system of claim 1 wherein said system has a thickness up to about 0.025 inch, said selected reinforcing mesh being aluminum of about 0.011–0.012 inch strand diameters and the balance of said thickness being said double base propellant composition.

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