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PROCESS FOR BONDING SALT TO METAL BALLISTIC ROD

Filed July 9, 1957

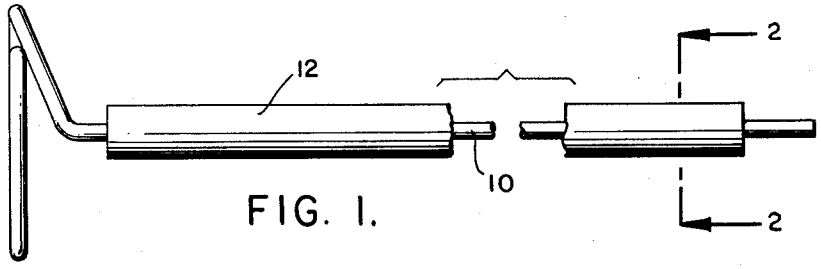
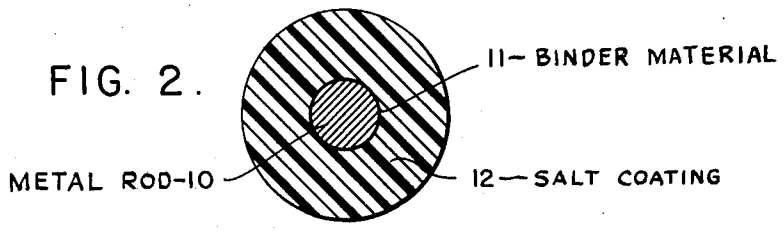


FIG. 1.

FIG. 2.



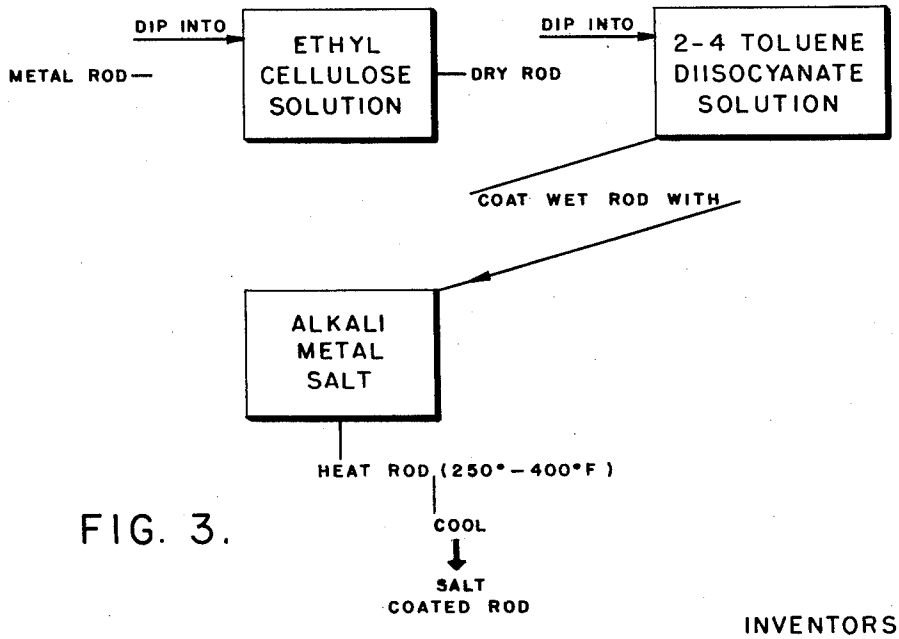


FIG. 3.

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PROCESS FOR BONDING SALT TO METAL BALLISTIC ROD

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4 Claims. (Cl. 117—62.2)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States without the payment of any royalties thereon or therefor.

The present invention relates to ballistic rods for rockets and more particularly to the process for bonding a salt coating to a metal ballistic rod. The present invention also relates to U.S. Patent No. 3,068,643 by Albert T. Camp, filed April 21, 1955, and entitled "Rocket With Internal Rod."

Ballistic rod assemblies are used to support an alkali metal salt, such as potassium sulfate, in the flame of burning rockets and allow such salt to get into the rocket exhaust for reasons as described in U.S. Patent No. 3,068,643. The present invention is concerned primarily with bonding the alkali metal salt coating to the metal rod. Old methods consisted of simply heat-bonding the salt coat to the ballistic rod. In the old processes the bond degenerated very rapidly when exposed to the propellant in a rocket due to plasticizer migration from the propellant, and after long periods of storage the salt coating would become completely separated from the rod. Rods bonded by old procedures degenerated faster than the rest of the rocket requiring rods to be removed from the rocket and replaced after a certain period of time or else discarding the rocket. The process of the present invention affords a bond for the salt coating which is much more impervious to the migration of plasticizer, such as nitroglycerin, than the earlier methods and allows the life of the rocket to be extended. The method of forming a salt coating bonded onto metal ballistic rods in the instant case involves dipping the metal rods in a solution of ethyl cellulose which has been dissolved in a mixture of toluene and acetone; drying the rods and then dipping them into toluene diisocyanate; the alkali metal salt coating is the applied and baked onto the rod.

It is therefore an object of this invention to provide a process for improved bonding of a salt coating to ballistic rods.

Another object of the present invention is to provide an improved bond for bonding an alkali metal salt to a metal.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same become better understood by reference to the following detailed description and the accompanying drawings in which:

FIG. 1 is an elevational view of a coated rod of the invention broken away near the center section;

FIG. 2 is a cross-section of the coated rod, on an enlarged scale, taken on line 2—2 of FIG. 1; and

FIG. 3 is a flow diagram illustrative of the process.

Referring to FIG. 1 there is shown a supporting rod **10** of incombustible material, such as metal, coated with an alkali metal salt **12** to be described later.

In FIG. 2 the numeral **11** indicates the bonding material which secures the salt coating **12** onto rod **10** in a cylindrical design to give efficient burning to the grain. Other designs of the coating such as cruciform and star-shaped forms made by extrusion or other methods may be used consistent with the shape of the internal performation of the propellant grain.

In FIG. 3 the process by which the composition is bonded to the rod is shown in a flow chart described below.

The process of bonding an alkali metal salt to metal ballistic rods consists of dipping the rods into a solution of ethylcellulose which has been dissolved in a mixture of 80% toluene and 20% acetone. The final solution contains approximately 5% ethylcellulose. After dipping in the ethylcellulose solution, the rods are dried and then dipped into 2,4-toluene diisocyanate. The salt coatings are then affixed or secured immediately, by extrusion for instance, so the metal rods and each ballistic rod assembly is heated to about 250 to 400° F., the melting point of the ethylcellulose plastic, without buckling or warping the alkali metal salt coating. The ballistic rod assemblies are then allowed to cool; after cooling, the results are completed rods.

One of the salt coatings successfully bonded to the metal rod and described in the above referenced Patent No. 3,068,643 consisted essentially of potassium sulfate, a well-known ballistic modifier, and ethyl cellulose, butyl methacrylate, dibutyl phthalate, polyglycol dimethacrylate and benzoyl peroxide. These ingredients were mixed together in a Sigma-blade type mixer until a dough of a homogeneous character resulted. The dough was placed in an extrusion press and extruded through a die having the desired diameter and containing a pin or stake. A tube was thus produced of the salt coating which was secured around the pretreated metal ballistic rod which had been wetted in 2,4-toluene diisocyanate solution as set out herein. The rod assembly was then enclosed in a mold, heated, and cooled. A firm bond between the salt coating and rod resulted.

The process can be varied by dipping the salt coat and the ethylcellulose coated rod in toluene diisocyanate prior to baking.

Adhesives of the epoxy, silicone, isocyanate, and rubber-base groups were tested for bonding the extruded alkali metal salt coating to ballistic rods. Only the isocyanates showed promise for this application. They showed an increase in bond strength over the salt coatings on rods with no adhesive. This indicated that some cross-linking must take place with the excess isocyanate of the adhesive coating. Such cross-linking provides some resistance to bond breakdown caused by plasticizer (nitroglycerin) migration from the rocket propellant which surrounds the ballistic rod when in a rocket. Several mixtures of isocyanates and ethylcellulose, diluted with a solvent of 20% acetone and 80% toluene were tried. One of the best combinations found was 10 parts toluene diisocyanate, 40 parts ethylcellulose and 310 parts of the mixed solvent containing 20% acetone and 80% toluene. The results were very good when this mixture was allowed to dry in a thin coat on the ballistic rods. Finally, the rods were dipped in toluene diisocyanate just before applying the alkali metal salt coating. A small amount of toluene diisocyanate may or may not be included in the ethylcellulose solution; it is only necessary that some toluene diisocyanate impregnate the ethylcellulose coating during the final dipping to assure a good bond. The operative range of ethylcellulose in solution is from 5 to 10%; up to 3% toluene diisocyanate may be used in the ethylcellulose solution.

Pull-test results on diisocyanate-bonded ballistic-rod coatings (assembled rods kept in the presence of rocket propellant up to 30 days) are listed in the table below. Also included are test results from rods bonded by the standard resistance-heating method using no adhesive.

Strength-Test Results on Diisocyanate-Bonded Coatings of 2.0-In. Ballistic Rods After Aging Inside Propellant Grains at 130° F.

Aging (days)	Sample Size Tested	Average Bond Strength (lbs. force/2-in. lgth.)				Ratio of Av. Strengths
		Diisocyanate Adhesive		No Adhesive		
		X	S	X	S	
0	5	280	45	188	8	1.5
7	5	253	30	137	19	1.8
15	5	189	29	65	15	2.9
30	5	139	16	31	19	4.5

The test results conclusively show that a much stronger bond is provided between the alkali metal salt and the metal rod than existed previously.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. The process of bonding an alkali metal salt coating to a metal ballistic rod for a rocket, comprising dipping the metal rod into a solution of ethylcellulose dissolved in a mixture of 80% toluene and 20% acetone, the final solution containing approximately 5 to 10% ethylcellulose, drying said rod, dipping the rod into 2,4-toluene diisocyanate and then immediately affixing around said rod a metal salt coating consisting essentially of potassium sulfate, ethyl cellulose, butyl methacrylate, dibutyl phthalate, polyglycol dimethacrylate and benzoyl peroxide, heating the rod assembly to a temperature from about 250 to 400 degrees Fahrenheit without warping the salt coating, and then cooling said rod; resulting in a bond between the salt coating and said rod which is greatly impervious to the plasticizer ingredients in a rocket propellant.

2. The process of bonding a potassium sulfate coating to a metal ballistic rod for a rocket, comprising dipping the metal rod into a solution of ethylcellulose dissolved in a mixture of 80% toluene and 20% acetone, the final solution containing approximately 5 to 10% ethylcellulose, drying said rod, dipping the rod into 2,4-toluene diisocyanate and then immediately affixing around said rod a potassium sulfate coating consisting essentially of potassium sulfate, ethyl cellulose, butyl methacrylate, dibutyl phthalate, polyglycol dimethacrylate and benzoyl peroxide, heating the rod assembly to a temperature of about 250 to 400 degrees Fahrenheit without warping the potassium sulfate coating, and then cooling said rod; resulting in a bond between the potassium sulfate coating and said rod which is greatly impervious to the plasticizer in a rocket propellant.

3. A process as in claim 2 wherein said final ethylcellulose solution contains up to 3% toluene diisocyanate.

4. A metal rod having a potassium sulfate coating bonded to the surface thereof by dipping the metal rod into a solution of from 5 to 10% ethylcellulose dissolved in a mixture of 20% acetone and 80% toluene, said solution containing up to 3% toluene diisocyanate, drying the metal rod, dipping the rod into 2,4-toluene diisocyanate and immediately affixing the potassium sulfate coating consisting essentially of potassium sulfate, ethyl cellulose, butyl methacrylate, dibutyl phthalate, polyglycol dimethacrylate and benzoyl peroxide, heating the rod with coating to about 250 to 400 degrees Fahrenheit, and then cooling the rod, resulting in a strong bond between the metal rod and the potassium sulfate coating.

References Cited in the file of this patent

UNITED STATES PATENTS

1,946,647	Taylor et al.	Feb. 13, 1934
2,104,428	Richardson	Jan. 4, 1938
2,162,027	Muskat	June 13, 1939