July 17, 1962 D. R. JONES 3,044,342

MILITARY DETONATORS

Filed May 7, 1958 2 Sheets-Sheet 1

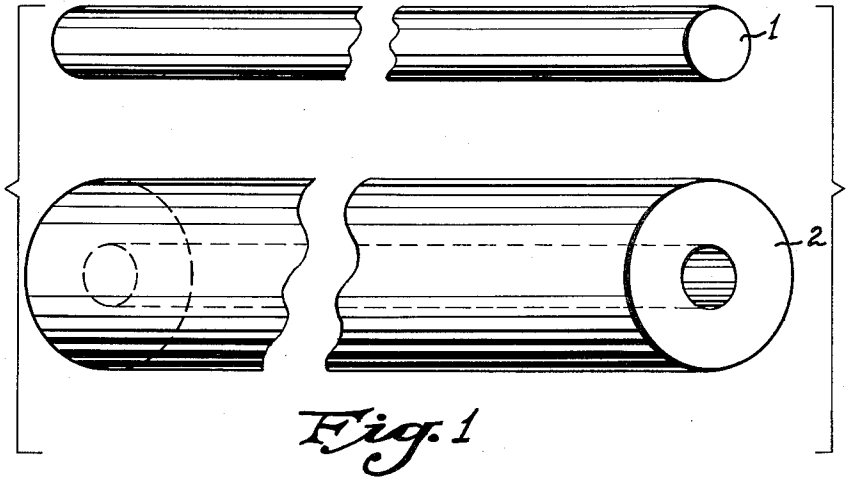


Fig. 1

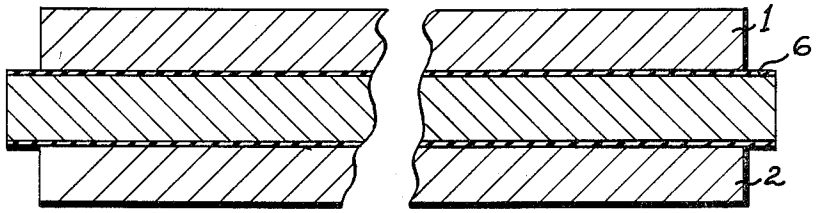


Fig. 2

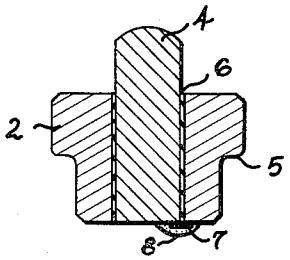


Fig. 3

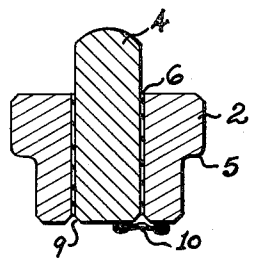


Fig. 4

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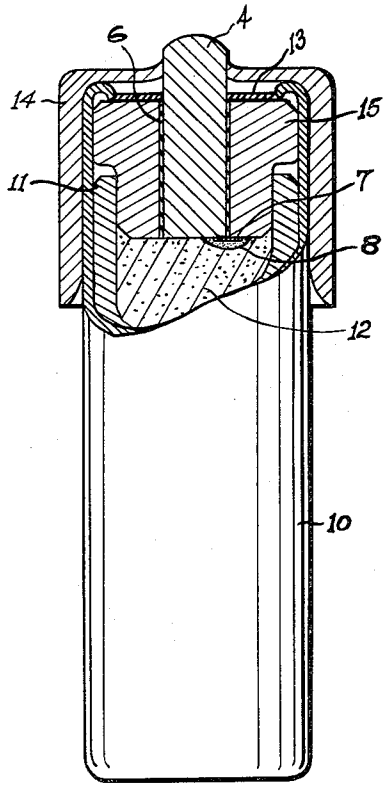


Fig. 5

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MILITARY DETONATORS

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This invention relates to electrically initiated detonators and particularly to such detonators adapted for the initiation of explosive charges in military projectiles and other explosive material.

Electrical detonators utilized for the initiation of explosive charges in projectiles and the like must necessarily meet very rigid structural and operational specifications. Detonators of this type are quite small, generally being less than an inch in length and in the neighborhood of ¼ of an inch in diameter. In addition, they must be capable of being initiated by low electrical energy. Furthermore, they must be exceedingly rugged to withstand the forces of setback when the projectile is fired. The explosive trains of this type of detonator either instantaneous or delay are of the usual type, but the bridge plug and igniter assembly must be designed to render them serviceable under severe operating conditions.

Generally, these military detonators are sealed with a two-piece bridge assembly. This assembly consists of a centrally located metal rod positioned within and separated from a metal tube or ring by a film of dielectric material. The lower portion of the plug is co-planar and the dielectric gap is spanned by a carbon bridge or fine resistance wire over which is placed a match head of lead styphnate or the like. One end of the centrally located metal rod extends slightly from the body of the bridge plug and from the detonator to serve as an electrical contact. These two-piece bridge plugs having a height of approximately 3/16 of an inch and a diameter of about 1/8 of an inch are generally prepared singly by inserting the rod provided with a lateral dielectric coating into the metal ring which has been internally coated with dielectric material. In order to facilitate such an assembly, the internal bore of the metal tubing is slightly coned with the larger diameter being at the upper or external portion of the plug. After assembly, the dielectric material is cured and the lower portion of the plug is machined to provide a one-plane surface with no burrs spanning the dielectric gap. Thus, as more of the lower portion of the plug is ground away, the gap between the rod and the tube becomes greater due to the conical inner surface of the tube. Therefore, it is exceedingly difficult, if not practically impossible, to provide detonators of this type having uniform electrical characteristics by prior art processes. Furthermore, it is difficult to obtain a firm bond between the two components of the bridge plug. This firm bond is important because in the manufacture of the detonators, it is essential to use the bridge plug as a press pin in positioning the igniter composition in the detonator. This operation often requires a pressure of approximately fifteen thousand pounds per square inch and results in the separation of a significant number of the prior art bridge plugs.

It is, therefore, an object of this invention to provide a method for the manufacture of metal detonator bridge plugs overcoming the disadvantages of the prior art. It is also an object of this invention to provide novel improved metal bridge plugs for low energy electrical detonators. It is a more specific object of this invention to provide an electrical detonator metal bridge plug having desirable physical characteristics and more uniform electrical properties. A further object of this invention is to provide a process by which such detonator bridge plugs can be readily produced.

In accordance with this invention, generally stated, these and other objects are achieved by coating a length of metal rod with an insulating material and an uncured thermosetting adhesive, swaging a metal tube about the rod, and machining the resultant assembly into the shape of detonator bridge plugs. More specifically, this invention contemplates the preparation of such bridge assemblies by coating a length of cylindrical metal rod with a liquid plastic insulating or dielectric material, permitting the insulating material to set and then positioning the metal rod in a metal tube having an internal diameter slightly greater than the diameter of the coated rod. The metal surfaces are separated by the dielectric material as well as by a layer of a thermosetting adhesive between the dielectric material and the internal surface of the tube. The tube is then swaged about the rod to form a tight fit. The assembled rod and tube are subjected to an elevated temperature to cure the thermosetting adhesive. After the thermosetting adhesive has completely set, the rod and tube assembly is cut and machined to form a plurality of bridge plug assemblies. This may be done most conveniently by feeding the assembly into a screw machine which forms the assemblies and makes face cuts to remove any burr which tends to bridge the insulation gap.

The rod and plug are both preferably formed of stainless steel, that is, steel containing nickel and/or chromium, but other grades of steel as well as other metals, such as nickel-copper alloys, and aluminum, can also be used. The insulating material is applied to the metal rod in the form of a solution or liquid suspension. While it is preferred to use a lacquer having a polyvinyl formal base, various other insulating coatings can be used with equal facility. For example, lacquers which are solutions of glyptal resins having as a base the reaction products of glycerol and aliphatic carboxylic acids, epoxy resins having as a base the reaction products of diphenylolpropane, epichlorohydrin, and amine catalysts, polyvinyl chloride, polyester resins formed by the reaction of polybasic alcohols with polyfunctional aliphatic or aromatic carboxylic acids, cellulose esters such as cellulose acetate, cellulose propionate, cellulose butyrate, and various types of paints will also provide adequate insulation for the bridge plug assembly of this invention. A thin coating of vitreous enamel can also be utilized in order to provide satisfactory insulation for the bridge plug assembly of this invention. Such a vitreous enamel coating will minimize or eliminate any insulation exudation difficulties which might be experienced with such assemblies.

Many types of liquid unpolymerized thermosetting plastic materials which upon heating are transformed into adhesive solids can be used to bond the components of the assembly. Suitable materials of this type include the epoxy resins, styrene, phenol-formaldehyde, methyl methacrylate, and the like. These adhesives can be applied to the rod by dip coating, by inserting a small amount of the adhesive into the tube before drawing the rod through it, or by any other suitable means. After the rod has been threaded through the tube, and the assembly swaged to an appropriate diameter, the adhesive is cured in situ by heating the assembly to or above the setting point of the material, but below its decomposition point. The time and temperature involved in the curing operation must necessarily vary with the type of material employed.

The manner in which the objects of this invention are achieved will be more readily understood by reference to the following specific embodiment when taken in connection with the drawing in which:

FIGURE 1 is a perspective view of the metal rod and metal tube forming the components of the bridge plug of this invention;

FIGURE 2 is a cross sectional longitudinal view of the rod and tube after assembly;

FIGURE 3 is a cross sectional view of a bridge plug made in accordance with this invention;

FIGURE 4 is a cross sectional view of a bridge plug representing another embodiment of this invention; and

FIGURE 5 is a longitudinal view partially in section of an electrical detonator containing the bridge plug of FIGURE 3.

As illustrated in FIGURE 1, a stainless steel rod **1** and a stainless steel right cylindrical tube **2** are provided. In accordance with this embodiment, these components are approximately 4 feet long, but may be of any desired length. Prior to assembly, both the rod and tube were thoroughly cleaned with acetone. The inside walls of the tube were then etched to insure cohesion between the components. This etching was accomplished with a mixture of approximately 50 parts nitric acid, 10 parts hydrochloric acid, and 100 parts water. This acid solution was removed with water followed by an acetone rinse. The tube was then heated to about 100° C. to completely dry it.

The stainless steel rods having a diameter of approximately 0.060 inch were coated with successive layers of a polyvinyl-formal base lacquer until a layer of approximately 0.0026 inch was obtained. The coated rods were then heated by passing an electric current through them until the lacquer was cured to a dark brown color. The adhesive used in this embodiment was a thermosetting epoxy resin. A slight vacuum was used to draw this liquid thermosetting adhesive into about 5 inches of the tube. The rod was inserted behind the resin taking care not to entrap any air between the rod and the resin. The rod was passed through the tube until about three inches of the rod extended from each end of the tube. The tube was then swaged about the rod and reduced from an outside diameter of about 0.22 inch to about 0.21 inch in one pass. This action increased the tube length about 2 inches, but had no effect on the dimensions of the rod. The rod and tube assembly was then heated for about 2 hours at 85° C. followed by 4 hours at a temperature of 150° C. to cure the resin.

The rod and tube assembly were fed into a screw machine to form a plurality of plugs that were machined to the general shape of the plug shown in FIGURE 3. As illustrated in FIGURE 3, a portion of the tube is removed from the upper end of each plug to expose the electrical contact or button **4** and the lower portion of the tubing is decreased in diameter to provide the plug with a shoulder **5**. The tube and the rod segments are separated from one another by the dielectric material and thermosetting adhesive illusrated generally at **6**. The plugs were then finished by making face cuts at each end to remove any burrs which tended to bridge the insulation gaps.

After the plugs had been mechanically and electrically inspected, they were placed in a 130° C. oven for 16 hours to relieve any stress that may have been present in the plastic materials. A small amount of plastic material exuded from each end of the plugs, and was removed by subjecting the plugs to a light abrasive vapor blast. The completed plugs were then provided with a carbon bridge shown at **7**. This carbon bridge is preferably applied in the form of an aqueous carbon suspension which is permitted to dry. After drying, the carbon bridge was covered with a suspension of basic lead styphnate in a nitrocellulose lacquer. This suspension was then dried so as to form match head **8**.

FIGURE 4 illustrates a bridge plug made as described above except that a groove **9** has been machined in the face of the plug at the dielectric ring or cylinder, and the gap so formed has been electrically bridged by a fine bridge wire **10** welded or soldered to the ring and plug.

FIGURE 5 illustrates generally an electrical detonator provided with a bridge plug assembly made in accordance with this invention. This detonator is provided with a

stainless steel case **10**, a stainless steel sleeve **11**, and an explosive train designated generally at **12**. The metal detonator is waterproofed by a layer **13** of any suitable lacquer. This detonator is also provided with a shunt **14**. The explosive train **12** is consolidated under considerable pressure, normally in the neighborhood of about 15,000 pounds per square inch. The final consolidation of this charge is achieved by pressing the bridge plug assembly composed of the rod **4** and the concentric metal portion **15** into the mouth of the detonator case. Thus, the bridge plug of this invention can be utilized as a press pin in the assembly operation.

The present invention provides an exceedingly rugged type of electric detonator with a metal bridge plug assembly that cannot be achieved by prior art processes. In addition, since the external surface of the rod and the internal surface of the tube are parallel, uniformity throughout the length of the bridge plug is insured. This eliminates any material deviation in the magnitude of the dielectric gap between the bridge plug components. Furthermore, such uniformity is maintained regardless of the amount of the inner surface of the plug that must be removed to render it co-planar and free from burrs.

While the above specific embodiment has been set forth in considerable detail, it will be readily understood that various deviations can be made without departing from the scope of the present invention. Thus, metals other than stainless steel may be utilized and in some instances, the metal of the tube can be different from that of the rod. Furthermore, various types of dielectric and adhesive materials can be utilized in lieu of those designated in the above embodiment.

What is claimed is:

1. In a process for the manufacture of bridge assemblies for electric detonators, the steps comprising coating a length of metal rod with a liquid solidifiable plastic insulating material, curing the insulating material, coating the rod with an uncured liquid thermosetting adhesive, inserting the rod into a length of metal tube, the plastic insulating material and the adhesive being the only means for positioning the rod within the tube, uniformly swaging the tube about the rod, heating the rod and tube above the setting point of the adhesive, cutting the rod with the tube swaged about it into segments and machining each segment into the shape of a detonator bridge plug.

2. In a process for the manufacture of bridge assemblies for electric detonators, the steps comprising coating a metal rod with a liquid solidifiable plastic insulating material, curing the insulating material, positioning uncured thermosetting adhesive in a metal tube, inserting the insulated rod in the end of the tube containing the adhesive so as to provide a continuous layer of the adhesive between the rod and the tube throughout their entire length, the insulating material and the adhesive being the only means for positioning and supporting the rod within the tube, uniformly swaging the tube about the rod, curing the adhesive between the rod and the tube, cutting the rod with the tube swaged about it into a plurality of segments and machining each segment into he shape of a detonator bridge plug.

3. In a process for the manufacture of bridge assemblies for electric detonators, the steps comprising coating a metal rod with a liquid solidifiable plastic insulating material, positioning uncured liquid thermosetting adhesive in one end of the metal tube, inserting the insulated rod into that end of the tube containing the adhesive so as to provide a continuous layer of the adhesive between the rod and the tube throughout their length, the insulating material and the adhesive being the only means for positioning and supporting the metal rod within the metal tube, uniformly swaging the tube about the rod, curing the adhesive beween the rod and tube, cutting the rod with the tube swaged about it into a plurality of segments and removing the tube, adhesive and insulation from one end of each segment to provide an exposed length of rod.

4. In a process for the manufacture of bridge assemblies for electric detonators, the steps comprising coating a metal rod with a liquid solidifiable plastic insulating material, curing the insulating material, positioning uncured liquid thermosetting adhesive in one end of a metal tube, inserting the insulated rod into that end of the tube containing the adhesive so as to provide a continuous layer of the adhesive between the rod and the tube throughout their length, the insulating material and the adhesive being the only means for positioning the rod within the tube, uniformly swaging the tube about the rod, curing the adhesive between the rod and tube, cutting the rod with the tube swaged about it into a plurality of segments, removing the tube, adhesive and insulation from one end of each segment to provide an exposed length of rod, and machining the opposite end of each segment to provide a flat surface.

5. In a process for the manufacture of bridge assemblies for electric detonators, the steps comprising dip-coating a length of steel rod with a liquid solidifiable plastic insulating material, curing the insulating material, filling a portion of a steel tube with an uncured liquid epoxy resin, inserting the coated rod into the tube so as to provide a continuous layer of epoxy resin between the rod and the tube throughout their length, uniformly swaging the tube about the rod, heating the rod and tube above the setting point of the resin, cutting the rod with the tube swaged about it into a multiplicity of segments, and machining each segment into the shape of a detonator bridge plug.

References Cited in the file of this patent

UNITED STATES PATENTS

2,071,432	Rohde	Feb. 23, 1937
2,356,337	Miller	Aug. 22, 1944
2,687,667	Gunther	Aug. 31, 1954
2,761,207	Dodd et al.	Sept. 4, 1956
2,762,302	MacLeod	Sept. 11, 1956
2,821,139	Apstein et al.	Jan. 28, 1958