United States Patent [19]

Langrish-Smith et al.

[11] **3,867,884**

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[54] **EXPLOSIVE FUSE-CORD**

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[52] **U.S. Cl.** ..... **102/27 R**

[51] **Int. Cl.** **C0bc 5/00**

[58] **Field of Search** 102/27

[56] **References Cited**

UNITED STATES PATENTS

3,260,201	7/1966	Kelly et al.	102/27
3,382,802	5/1968	Prior et al.	102/27
3,407,731	10/1968	Evans	102/27
3,712,222	1/1973	Richardson et al.	102/27
3,730,097	5/1973	Helfgeni et al.	102/27

FOREIGN PATENTS OR APPLICATIONS

1,120,200	7/1968	Great Britain	102/27

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[57] **ABSTRACT**

An explosive fuse-cord having an inner explosive core and an outer waterproofing sheath of a copolymer of ehtylene and from 7 to 30 percent by weight of the copolymer of vinyl acetate or alkyl acrylate or alkyl methacrylate wherein the alkyl group contains from 1 to 4 carbon atoms.

10 Claims, No Drawings

EXPLOSIVE FUSE-CORD

This invention relates to an explosive fuse-cord having an improved waterproof thermoplastics sheath.

Explosive-fuse cord normally comprises a core of explosive material surrounded by reinforcing wrappings, for example natural or synthetic textile yarns. Thus, detonating cord usually has a core of PETN (pentaerythritol tetranitrate) and safety fuse has a blackpowder core. The core is often encased in a thin envelope of paper or plastics film. Reinforcing yarns are applied around the envelope and a waterproof sheath of thermoplastics is applied over the yarns, usually by extrusion. The waterproof sheath usually consists of plasticised polyvinyl chloride (PVC) or polyethylene and the required extrusion temperature exceeds 160°C, which is higher than the melting point of PETN (141°C). Thus, there is a substantial risk of excessive heating and ignition of PETN during the extrusion process and such incidents have been reported. Clearly, it would be advantageous to use sheathing material which can be extruded at a lower temperature.

We have now found that certain copolymers of ethylene and vinyl acetate or alkyl acrylates or alkymethacrylates may be advantageously used for this purpose. Not only can they be extruded at a lower temperature, but they give fuse-cords with other deisrable properties.

In accordance with this invention, an explosive fuse-cord comprises an inner explosive core and an outer water-proofing sheath of a copolymer of ethylene and from 7 to 30 percent by weight of the copolymer of vinyl acetate or an alkyl acrylate or an alkyl methacrylate wherein the alkyl group contains from 1 to 4 carbon atoms. Suitable acrylates and methacrylates include ethyl and butyl acrylate and methyl methacrylate.

The preferred copolymer is a copolymer of ethylene and vinyl acetate. The copolymers should preferably have a melt flow index of from 0.1 to 25 and more preferably 1 to 7 as measured according to British Standard 2782 Part 1/105 C/1970 using a 2.16 Kg load.

As the melting point of the copolymer is lower than that of polyethylene, the copolymer is conveniently applied to the fuse-cord by extrusion, preferably pressure extrusion, high quality extruded sheaths being obtained at extrusion temperatures much lower than those hitherto necessary for extruding external sheaths on explosive fuse-cord. Thus, in the manufacture of detonating cord having a core of PETN, the extrusion temperature can be maintained below the melting point of the PETN.

The fuse-cord advantageously comprises one or more reinforcing layers of textile wrappings wound around the explosive core as in the conventional fuse-cords. Textile wound fuse-cords have hitherto had low water resistance largely because of the tendency for water to migrate by capillary action along the textile layer and enter the explosive core from the side over long distances from a cord end immersed in water. We have

surprisingly found that the copolymer used in this invention enters the interstices in the textile layer during the extrusion and the migration of water through the textile layer is largely prevented. The water resistance of the fuse-cord is thereby improved. Fuse-cords having especially good water resistance may be prepared when the textile wrappings comprise fibrillated thermoplastics yarn, for example fibrillated polypropylene. Fibrillated polypropylene yarn which has been coated with a hot melt adhesive comprising a copolymer of ethylene and vinyl acetate is particularly useful in this respect. Examples of such hot melt adhesives are mentioned in West German patent application specification No. 2,203,261.

For certain applications where there is a risk of the fuse-cord acquiring an electrostatic charge, the copolymer sheath may be advantageously rendered conducting by the incorporation of finely divided carbon whereby any charge can be readily dissipated to earth.

In addition to the aforementioned advantages, the fuse-cord of the invention is more flexible at low temperatures and is surprisingly more abrasion resistant than fuse-cords with sheaths of polyvinyl chloride or polyethylene. It is therefore more suitable for use in severe conditions, for example in frozen areas and for suspending charges in rough shotholes.

The invention is further illustrated by the following Examples of detonating cord, of which Examples 1 and 2 have conventional sheaths of PVC or polyethylene and are included for comparison, whereas Examples 3 to 5 are in accordance with the invention.

The detonating fuse-cords were made by a commonly used fuse-cord manufacturing method as described, for example, in United Kingdom Patent Specification No. 1,120,200. They had an explosive core consisting of crystalline PETN loaded at a charge rate of 10 g per metre surrounded by a paper tube of 0.18 mm thick. The paper tube was covered with a helically spun reinforcing layer of 10 strands of 1,000 denier pin-roll fibrillated polypropylene tape having a width of 2.5 mm and a thickness of 0.01 mm spun at 26 turns per metre followed by a helically counterspun layer consisting of 8 strands of the same pin-roll fibrillated polypropylene tape spun at 39 turns per metre. A thermoplastics sheath 0.4 mm thick was extruded around the polypropylene layers by means of a cross-head extrusion machine, the sheets of Examples 3 to 5 being extruded under pressure.

In Example 1 the sheath was PVC plasticised with 36 parts of di-isooctylphthalate per 100 parts of PVC. In example 2 the sheath was low density polyethylene. In Examples 3 to 5 it was a copolymer of ethylene and vinyl acetate (VA) comprising 7 percent, 18 percent and 28 percent respectively by weight of vinyl acetate, the melt flow index of the copolymers being 2. The properties of the fuse-cords of Examples are given in the following Table.

TABLE

Example Sheath material	1 Plasticised PVC	2 Low Density Polyethylene	3 Ethylene/vinyl acetate copolymer 28% VA	4 Ethylene/vinyl acetate copolymer 18% VA	5 Ethylene/vinyl acetate copolymer 7% VA
Extrusion head temperature	170°C	165°C	110°C	130°C	135°C
Abrasion resistance (average No. of passes for puncturing)	2.5	12.8	7.5	16.4	18.0

TABLE—Continued

Example Sheath material	1 Plasticised PVC	2 Low Density Polyethylene	3 Ethylene/vinyl acetate copolymer 28% VA	4 Ethylene/vinyl acetate copolymer 18% VA	5 Ethylene/vinyl acetate copolymer 7% VA
Low temperature performance					
Cold flex temperature	−22°C	—	−40°C	−39°C	−39°C
Cold bend temperature	−45°C	—	−70°C	−70°C	−70°C
Charpy embrittlement temperature	—	−10 to −20°C	−30 to −35°C	−30 to −35°C	−30 to −35°C
Water resistance (Average penetration after 24 hours)	110 cm	110 cm	16 cm	17 cm	17 cm
Gap propagation	16 mm	16 mm	16 mm	16 mm	16 mm
Velocity of detonation	6.8	6.8	6.8	6.8	6.8
Tensile strength	>100 Kg	>100 Kg	>100 Kg	>100 Kg	>100 Kg

The abrasion resistance was determined by suspending a length of fuse-cord, with a 3 Kg weight attached to one end, over the right angled edge of a concrete block whilst the other end was maintained at an angle of 30° to the horizontal. The cord was passed repeatedly over the concrete edge until the sheath became punctured. The average number of passes required are given for each sample.

The low temperature performance was measured as the temperature at which the sheath became brittle or too stiff to allow lengths of the cord to be knotted together. The cold flex temperature was determined according to British Standard 2782 Part 1/104B/1970, the cold bend temperature was determined according to British Standard 2782 Part 1/104B/1970 and the Charpy embrittlement temperature was determined according to British Standard 2782/306E/1970.

The water resistance was determined by vertically suspending lengths of fuse-cord with an exposed end immersed under a head of 1.6 metres of water for 24 hours and measuring the distances to which water had penetrated along the cord.

In the gap propagation test two lengths of fuse-cord were maintanied parallel and at a measured distance apart with an air gap between them. The maximum distance over which detonation was communicated from one length to the other was determined.

The test results given in the Table show that the fuse-cords of Examples 3 to 5 were sheathed at a temperature below the melting point of PETN. They were superior in abrasion resistance, water resistance and flexibility to the fuse-cords sheathed with PVC and polyethylene and in explosive and mechanical properties they were at least equal to the latter fuse-cords.

What we claim is:

1. An explosive fuse-cord comprising an inner explosive core and an outer waterproofing sheath of a copolymer of ethylene and vinyl acetate containing from 7 to 30 percent by weight of the latter.

2. An explosive fuse-cord as claimed in claim **1** wherein the copolymer has a melt flow index of from 0.1 to 25.

3. An explosive fuse-cord as claimed in claim **1** wherein the copolymer is applied to the fuse-cord as a pressure extruded sheath.

4. An explosive fuse-cord as claimed in claim **3** wherein the explosive core is PETN and the sheath is extruded at a temperature below the PETN melting point.

5. An explosive fuse-cord as claimed in claim **1** comprising reinforcing layers of textile wrapping wound around the explosive core.

6. An explosive fuse-cord as claimed in claim **5** wherein the textile wrappings comprise fibrillated thermoplastics yarn.

7. An explosive fuse-cord as claimed in claim **6** wherein the fibrillated thermoplastics yarn comprises fibrillated polypropylene.

8. An explosive fuse-cord as claimed in claim **7** wherein the fibrillated polypropylene yarn is coated with a hot melt adhesive comprising a copolymer of ethylene and vinyl acetate.

9. An explosive fuse-cord as claimed in claim **1** wherein the copolymer sheath contains finely divided carbon.

10. An explosive fuse-cord comprising an inner explosive core of meltable material and an outer waterproofing extruded sheath of a copolymer of ethylene and vinyl acetate containing from 7 to 30 percent by weight of the latter, said sheath being extruded around said core at a temperature below the melting point of said core.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,867,884 Dated Feb. 25, 1975

Inventor(s) Michael Anthony LANGRISH-SMITH and Daniel STEELE

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the front page format after paragraph "[21]", insert:

--[30] Foreign Application Priority Data
February 19, 1973 Great Britain..... 7994/73--

Signed and sealed this 24th day of June 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
and Trademarks

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