May 11, 1937. G. S. LOBDELL 2,079,943

INSULATED ELECTRICAL CONDUCTOR

Original Filed Oct. 26, 1932

Fig. 1.

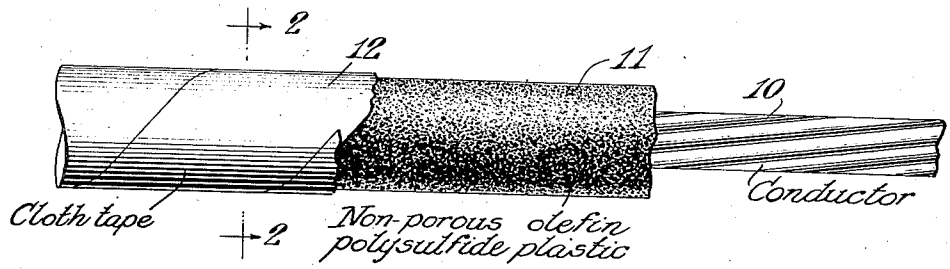


Fig. 2.

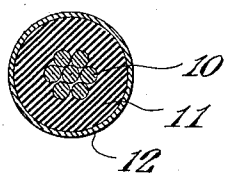


Fig. 3.

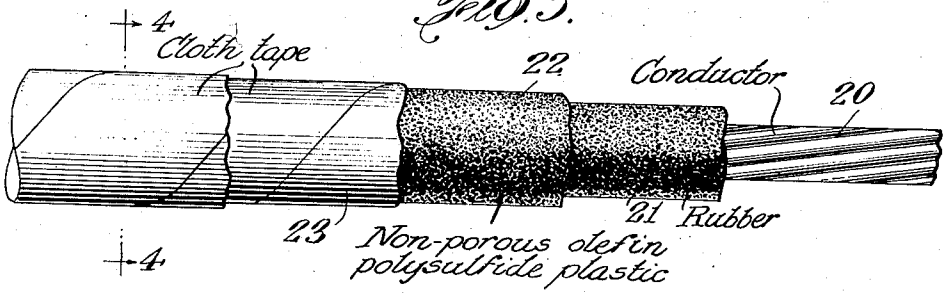
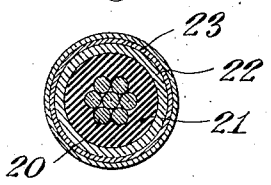


Fig. 4.



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INSULATED ELECTRICAL CONDUCTOR

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Application October 26, 1932, Serial No. 639,594
Renewed June 1, 1936

16 Claims. (Cl. 173—264)

This invention relates to insulated electrical conductors. It is an object of the invention to provide improved insulated conductors. Other objects and advantages of the invention will appear hereinafter.

An illustrative embodiment of the invention selected merely for descriptive purposes is shown in the accompanying drawing, in which:

Fig. 1 is an enlarged longitudinal elevation of a section of insulated conductor with the insulating layers removed progressively greater distances to disclose the construction;

Fig. 2 is a section through the conductor of Fig. 1 substantially on the line 2—2;

Fig. 3 is an enlarged longitudinal elevation of another section of insulated conductor with the insulating layers removed progressively greater distances to disclose the construction; and

Fig. 4 is a section through the conductor of Fig. 3 substantially on the line 4—4.

This application is a continuation in part of my application Serial No. 619,410, filed June 27, 1932.

The plastic substance disclosed in Canadian Letters Patent No. 290,645, June 18, 1929, to Joseph C. Patrick, consists mainly of organically combined sulfur. This plastic substance may be formed by the interaction of halogen additive compounds of olefins with polysulfides, for example, by the interaction of ethylene dichloride and sodium polysulfide, and merely for convenience in description may be described as an olefin polysulfide reaction product, and in the exemplary case as a condensation product of ethylene dichloride and an alkali polysulfide. This substance, which is a combination of carbon, hydrogen and sulfur, has certain physical properties resembling those of rubber. The hardness of this substance may vary over a wide range, dependent on the sulfur content, from a hard product to a soft elastic product. For the insulation of flexible electrical conductors the sulfur content desirably is about 82% to 83%.

The properties of this substance differ from those of rubber in a number of important respects. This plastic substance is highly resistant to decomposition by oils, acids and alkalis, and is substantially insoluble in practically all known acids, alkalis and organic solvents. It often is desirable that the insulation of electrical conductors be immune to attack by oils, acids, alkalis and organic solvents. For example, rubber-insulated ignition wire used in internal combustion engines deteriorates rapidly because of the oil which comes in contact with the rubber. In chemical plants, rubber-insulated wires and cables must be replaced at short intervals because of the injurious effects of acids and alkalis on the rubber. The problem in chemical plants is of such moment that wherever possible bare conductors are being substituted for insulated conductors because of the short life of rubber and other known insulating materials.

This plastic substance has a further important advantage over rubber as an electrical insulating material for the reason that this plastic substance is very highly resistant to injury by the effects of electrical corona. In rubber-insulated conductors used at medium or high voltages, particularly if the rubber is also under physical stress such as is caused by bending the conductors, the ozone which is formed by the corona cuts and destroys the rubber. Experimental tests have shown that this plastic substance is substantially unaffected by corona, and that for the same thickness of insulation it may be used at high voltages and under physical conditions which are prohibitive for rubber.

When used for insulating electrical conductors, these olefin polysulfide reaction products desirably are mixed with fillers and curing agents in somewhat the same manner as rubber. The term "olefin polysulfide reaction products" is used herein to include such mixtures in the same sense that "rubber" is used as a broad term to include mixtures of pure rubber with fillers and curing agents.

Olefin polysulfide reaction products may be cured by heating in a manner somewhat similar to that used in curing rubber, as by the open steam process, but when so cured the resultant substance is very spongy and porous. Although olefin polysulfide reaction products are cured by heating, the word "cured" has an entirely different significance than when used with reference to rubber. In the case of rubber, curing comprises the combination of the rubber with sulfur, whereas in the case of olefin polysulfide reaction products, curing comprises the production of a stable chemical compound from an unstable form of the same compound. Cured olefin polysulfide reaction products loaded sufficiently to reduce porosity have a low resistance to fatigue and crack rather easily, and the dielectric qualities are not satisfactory for use in insulating electrical conductors. During the curing of olefin polysulfide reaction products by the heat process a disagreeable gaseous decomposition product is given off having the characteristics of tear gas. The

formation of this gas makes the handling and curing of the substance more difficult.

The difficulties encountered in curing olefin polysulfide reaction products may be partially overcome by the addition of rubber. It has been found that the addition of very small quantities of rubber does not seriously affect the resistance of the resulting mixture to oils, acids, alkalis, and organic solvents. However, if rubber is added in sufficient quantities to materially reduce the porosity and sponginess of the cured product, the resistance to oil and to the effects of electrical corona are greatly reduced.

It is believed that the objectionable porosity and sponginess in the cured olefin polysulfide reaction products is caused by the formation of the gaseous decomposition product, probably a thio-aldehyde, in the substance during the heating process. Other substances may be added to accelerate the curing of the olefin polysulfide reaction products, but in the manufacture of insulated wires it is impractical to use an accelerator sufficiently rapid to effect complete curing of the substance before gas is formed in any substantial quantity. The reason for this is that the use of such a rapid accelerator would result in the precuring of the substance on the rolls and in the extruding machines before the substance is on the wire. Furthermore, such a rapid accelerator would result in any rubber in the mixture being overcured.

Applicant has found that olefin polysulfide reaction products may be heat treated to give a substantially non-porous product by adding to the compound before heating another substance which substantially prevents the formation of free gas in the compound. It is believed that this added substance combines with the gaseous decomposition product to form a condensation product with a low vapor pressure, thereby substantially preventing the formation of pores and holes in the compounds. Such substances are found in the classes of primary aromatic amines, naphthylamines, naphthols and phenols, and contain the group NH_2 or the group OH combined with radicals which so limit the activity of these groups as to cause the prevention of gas formation to take place under curing conditions. In this use the chemical activity of the individual members of these classes varies, and therefore the most effective member of these series of compounds is determined by the conditions of curing the olefin polysulfide reaction products. For example, applicant has found that a small amount of orthotoluidine incorporated in an olefin polysulfide reaction product before curing permits curing in a solid, non-porous compound in open steam. One suitable mixture for a cure of fifty minutes at 287° F. is as follows:

Olefin polysulfide reaction product	gm.	500
Smoked sheets	gm.	75
Zinc oxide	gm.	50
Diphenylguanidine	gm.	4
Orthotoluidine	c.c.	5
Sulfur	gm.	5
Talc	gm.	140

This compound has excellent electrical properties and exhibits a high resistance to oils, acids, alkalis and organic solvents.

If the electrical properties are not of primary importance, as where the compound is to be used as a sheath enclosing an insulated conductor, a different mixture may be preferable. In such a compound it is desirable that the resistance to oils, acids, alkalis and organic solvents be a maximum. One suitable mixture for a cure of 50 minutes at 287° F. is as follows:

Olefin polysulfide reaction product	gm.	500
Smoked sheets	gm.	50
Diphenyl-guanidine	gm.	4.5
Orthotoluidine	c.c.	5
Zinc oxide	gm.	50
Talc	gm.	100
Stearic acid	gm.	5
Phenyl beta naphthylamine	gm.	5
Carbon black	gm.	50
Sulfur	gm.	5

For somewhat softer cured compounds applicant has found that beta-naphthylamine is suitable for preventing porosity, while for still softer stock, beta-naphthol may be used in lieu of orthotoluidine. Olefin polysulfide reaction products cured in accordance with this invention have characteristics which make them highly desirable as coverings for electrical conductors. The cured product is flexible and elastic, and resembles rubber in these respects. The cured product is firm and substantially non-porous. The product retains its high resistance to oil and chemicals, and also to the effect of corona discharge. The substance may be milled and handled in much the same manner as rubber, and the formation of the objectionable gas during such handling is largely avoided. This plastic substance and the method of curing are disclosed and claimed in my copending application Serial No. 639,733, filed October 26, 1932.

Plastics made in accordance with this invention may be used as insulation on single or multiple strand conductors, and may be applied in substantially the same manner as rubber, for example by extruding. If desired, the olefin polysulfide plastic may replace rubber and comprise the entire electrical insulation for the conductor. However, it may be desirable to cover the conductor with a sheath of rubber only slightly thinner than the normal thickness of rubber insulation, and then apply a continuous thin protective wall of olefin polysulfide plastic over the rubber insulation. In such a construction the rubber is effectively protected by the olefin polysulfide reaction product wall against oils and acids, as well as against ozone which may be formed by corona discharge. It will be apparent that suitable jackets or armorings, for example wrappings of cloth tape, may be applied over the insulating jacket in the same manner as is done at present with rubber insulated conductors.

Referring to Figs. 1 and 2 there is shown merely by way of illustration a multiple strand conductor **10** enclosed in a sheath **11** of olefin polysulfide reaction product over which is a wrapping **12** of cloth tape. A modified construction is shown in Figs. 3 and 4 in which a conductor **20** is enclosed in a sheath **21** of rubber over which is a relatively thin wall **22** of olefin polysulfide reaction product and a spirally wrapped cloth tape **23**.

The foregoing description of certain specific embodiments of the invention is illustrative merely, and is not intended as defining the limits of the invention.

I claim:—

1. An insulated electrical conductor comprising in combination a conductor, a sheath of rubber, and a relatively thinner outer sheath of substantially non-porous olefin polysulfide reaction product which has been heat treated in the presence

of a gas formation retarding substance selected from the classes of aromatic amines, napthol and phenols containing respectively the group NH_2 and the group OH combined with radicals which so limit the activity of the groups as to cause the reduction of gas formation in the product under curing conditions

2. An insulated electrical conductor comprising in combination a conductor, a sheath of rubber, and a relatively thinner outer sheath of substantially non-porous olefin polysulfide reaction product which has been heat treated in the presence of a primary amine substance capable of combining with a gaseous product formed in the olefin polysulfide reaction product during heating to yield a condensation product.

3. An insulated electrical conductor comprising in combination a conductor, and a sheath of a substantially non-porous plastic olefin polysulfide reaction product which has been heat treated in the presence of orthotoluidine.

4. An insulated electrical conductor comprising in combination a conductor, and a sheath of a substantially non-porous plastic olefin polysulfide reaction product which has been heat treated in the presence of beta-naphthylamine.

5. An insulated electrical conductor comprising in combination a conductor, and a sheath of a substantially non-porous plastic olefin polysulfide reaction product which has been heat treated in the presence of beta-naphthol.

6. An insulated electrical conductor comprising in combination a conductor, and a sheath of substantially non-porous olefin polysulfide reaction product which has been heat treated in the presence of a primary amine substance capable of combining with a gaseous product formed in the olefin polysulfide reaction product during heating to yield a condensation product.

7. An insulated electrical conductor comprising in combination a conductor, and a sheath of substantially non-porous condensation product of ethylene dichloride and an alkali polysulfide which has been heat-treated in the presence of a primary amine compound having the property of preventing or retarding the formation of gas in said condensation product.

8. An insulated electrical conductor comprising in combination, a conductor, a sheath of rubber, and a relatively thinner outer sheath of substantially non-porous olefin polysulfide reaction product which has been heat treated in the presence of orthotoluidine.

9. An insulated electrical conductor comprising in combination a conductor, and a sheath of a substantially non-porous plastic olefin polysulfide reaction product which has been heat treated in the presence of a napthol compound which contains the group OH combined with radicals which so limit the activity of this group as to cause the prevention of gas formation to take place under curing conditions.

10. An insulated electrical conductor comprising in combination a conductor, and a sheath of a substantially non-porous plastic olefin polysulfide reaction product which has been heat treated in the presence of an amino-base compound which contains the group NH_2 combined with radicals which so limit the activity of this group as to cause the prevention of gas formation to take place under curing conditions.

11. An insulated electrical conductor comprising in combination, a conductor, a sheath of rubber, and a relatively thin outer sheath of substantially non-porous olefin polysulfide reaction product which has been heat treated in the presence of beta-naphthylamine.

12. An insulated electrical conductor comprising in combination, a conductor, a sheath of rubber, and a relatively thin outer sheath of substantially non-porous olefin polysulfide reaction product which has been heat treated in the presence of beta-naphthol.

13. An insulated electrical conductor comprising in combination, a conductor, and a sheath of a substantially non-porous, plastic olefin polysulfide reaction product which has been heat treated in the presence of a mono-amino derivative of an aromatic hydrocarbon of a hexacarbocyclic ring on to which is substituted an alkyl group in the ortho position.

14. An insulated electrical conductor comprising in combination, a conductor, and a sheath of substantially non-porous olefin polysulfide reaction product which has been heat treated in the presence of a primary amine compound having the property of preventing or retarding the formation of gas in said olefin polysulfide reaction product.

15. An insulated electrical conductor comprising in combination a conductor, and a sheath of substantially non-porous olefin polysulfide reaction product which has been heat treated in the presence of a substance from the group consisting of orthotoluidine, beta-naphthylamine and beta-naphthol.

16. An insulated electrical conductor comprising in combination a conductor, and a sheath of a substantially non-porous plastic olefin polysulfide reaction product which has been heat treated in the presence of a phenol compound which contains the group OH combined with radicals which so limit the activity of this group as to cause the prevention of gas formation to take place under curing conditions.

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