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LEAD CABLE SHEATH CONTAINING LITHIUM

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The present invention relates to leaden cable sheaths containing lithium.

It is well known that leaden cable sheaths have been subjected to deterioration and failure during service. In particular, leaden cable sheaths have been subjected to a complex phenomenon which has recently been known in the art as "inter-crystalline cracking". The history of the art relating to cable sheaths is summarized by R. S. Dean and J. E. Ryjord in their article in Metals and Alloys (volume I, No. 9, March 1930) as follows:

"The first cable sheathing was made of pure lead. While this material is still used in some instances, particularly in power cables, it was gradually replaced with an alloy of lead with 1–3% tin due to the greater strength of the latter, as well as greater resistance to certain types of corrosion. In 1907 the Bell System began an investigation to develop a cable sheath alloy which would be as good as the tin alloy but cheaper. This resulted in the adoption of the 1% antimony, 99% lead, as the standard sheathing for telephone cables.

"Cable sheath alloys must necessarily be pliable so that they may be easily reeled and unreeled. Further, they must be capable of forming into sheathing at a temperature which will not damage the insulating material of the cables, which, in the case of telephone cables, is paper. Lead is the only common and cheap material which meets these requirements and it appears that so long as we adhere to paper insulation and the seamless tube type of sheathing, we will be restricted to lead or its alloys for cable sheath.

"The sheath in service requires resistance to corrosion and to failure from fatigue and tensile stresses.

"The failure from intercrystalline corrosion has been very widely studied. Failure from this case in practice has, however, doubtless been greatly over-rated since fatigue failures have a very similar appearance.

"It has been generally observed that the presence of a small amount of a second element in solid solution in the lead prevents intercrystalline breakdown from corrosion alone even under drastic treatment with lead acetate and nitric acid (Rawdon's reagent) (H. S. Rawdon: Proceedings American Society for Testing Mater. 18: Pt. II, 189–200—1918—). Lead-antimony and lead-tin alloys are accordingly free from this type of corrosion.

"Other types of corrosion are of importance in special cases, but it appears the failure of cable sheath from simple corrosion is a rather rare case.

"Practically all the high lead alloys then, with the definite exception of magnesium alloy, are suitable for cable sheath from a corrosion standpoint and we have to concern ourselves principally with the mechanical properties, which affect extrudability and durability in service.

"In selecting mechanical properties it is necessary to compromise between pliability and high strength. A study of installation and service conditions leads to a tensile value of around 4000 lbs./in.^{2} as the most desirable value. This strength should, of course, be accompanied by the maximum possible fatigue limit."

Although proposals have been made to explain the theory and value of cable sheathing and, particularly, the so-called "inter-crystalline failure", nothing has been discovered for completely and satisfactorily explaining the failure and for eliminating such failures of commercial cable sheaths. Various proposals have been made but none, as far as I am aware, have been wholly satisfactory and acceptable. Thus, for instance, additions of tin, cadmium, antimony and/or the like to cable sheaths have been tried out in practice. These proposals have their disadvantages and have been discussed in the literature and in the art and Schumacher and Bouton summarized the situation in an article published in Metals and Alloys (Volume I, No. 9, March, 1930). In this article Schumacher and Bouton make the following statements:

"In the past few years, a number of investigators have studied the failure of lead cable sheath by cracking. After the investigation of many possible causes for this type of failure, it has come quite generally recognized that the alternate stress caused by vibration or daily or seasonal temperature changes are primarily responsible."

Attempts have been made to improve the resistance of lead to this type of failure by alloying it with one or more other metals. Those usually considered are Sn, Sb, and Cd in various concentrations. At present, in the United States of America, a large proportion of the telephone cables are being covered with a lead-1% antimony alloy. This alloy can be age-hardened and has been shown to possess considerably greater fatigue resistance than pure lead or lead tin alloys containing up to 3% Sn. It has one decided disadvantage, however, in that agglomeration of the precipitated particles takes place rapidly at room temperature, particularly when

the alloy is cold worked. This agglomeration is most pronounced near the grain boundaries and leaves large areas in this region unstrengthened by the dispersed phase. The art, therefore, has been confronted with a vexatious problem of replacing cable sheaths of lead, of antimony containing lead, and of tin containing lead with cable sheaths which are free from the disadvantages mentioned in the prior art.

I have discovered that a leaden cable sheath containing lithium within a critical range gives improved and unexpected results.

It is within the contemplation of the invention to provide a leaden cable sheath containing such small and restricted quantities of lithium that the final product has improved physical properties including higher tensile strengths and ductility and is substantially free from failure in service.

The invention also contemplates the provision of a leaden cable sheath containing such minute amounts of lithium that the melting point of lead is hardly changed, while at the same time the crystal structure is affected markedly with the production of very fine grains which are present in the as-cast condition and which persist even upon working, annealing, aging and the like.

It is a further object of the invention to provide a leaden cable sheath containing lithium in such amounts that the cost of production is economical and that commercial manufacture can be carried out satisfactorily and successfully.

Other objects and advantages of the invention will become apparent from the following description:

In carrying the present invention into practice, lithium is added in restricted amounts within a critical range to lead. It has been discovered that the critical range extends from about 0.002% to about 0.01%. Within this range it has been found that a range up to 0.005% is preferred. Cable sheaths made from lead with the foregoing restricted amounts of lithium have been found to possess improved properties in the as-cast condition and as worked, annealed, aged, etc. Thus, for instance, the tensile strength of the new cable sheath alloys are approximately twice that of lead. Furthermore, the occurrence of very fine grains assures a uniformity of the improved physical properties and a resistance to corrosive influences. The fatigue limit is considerably higher than that of lead, thus tending to prevent the occurrence of intercrystalline cracking during service.

With the improved leaden cable sheaths containing the restricted amounts of lithium, it has been found that the addition of amounts of cadmium within a critical range gives further improvements. It has been discovered that the cadmium must be restricted to a range of 0.15% to 0.18%. When cadmium is added to the present lead cable sheath containing minute amounts of lithium high elongations are obtained. This is in distinct contrast with the prior art cable sheaths in which the addition of cadmium above 0.20% reduces the elongation. In connection with the addition of cadmium to the improved lead-lithium cable sheath, it has also been discovered that when amounts above 0.20% are added, cadmium is precipitated from the lead as such or as a compound which tends to agglomerate and to lower the resistance to fatigue.

As a result of extended research and numerous experiments, it has likewise been discovered that the incorporation of controlled amounts of antimony to the improved low lithium lead cable sheaths produces an improvement provided the addition of antimony is kept below 0.5%. By controlling the amount of antimony to less than 0.5% in the low lithium-lead cable sheath the agglomeration of antimony particles which usually occurs in lead-antimony cable sheaths is prevented. With the present low lithium-lead cable sheaths, controlled amounts of antimony may be added in accordance with the foregoing without the disadvantages of prior cable sheaths containing antimony while at the same time providing certain advantages.

By the application of a special thermal threatment, it has been found that the properties of the improved low lithium-lead cable sheaths can be improved. Thus, for instance, when a leaden cable sheath containing minute amounts of lithium is heated at temperatures of about 300° C. prior to, during, or after working, improved results have been obtained. Then again, annealing after working or working at temperatures of about 150° C. to about 200° C. has been found to give improved properties. By annealing the improved lithium-lead cable sheaths at temperatures up to about 200° C. for a period of time, the sheaths can be artificially aged.

It is to be observed that the present invention provides a lead cable sheath in which low controlled amounts of lithium are incorporated to produce new results. Apparently the controlled amounts of lithium have a stabilizing effect which is believed to prevent agglomeration from occurring.

Although the present invention has been described with respect to certain specific embodiments, it is to be observed that modifications and variations are within the scope of the invention as defined by the appended claims as one skilled in the art will readily understand.

What is claimed is:

1. A lead cable sheath containing about 0.002% to about 0.01% lithium.

2. A lead cable sheath containing about 0.002% to about 0.005% lithium.

3. A lead cable sheath containing about 0.002% to about 0.01% lithium and about 0.15% to about 0.18% cadmium.

4. A lead cable sheath containing about 0.002% to about 0.01% lithium and a minor amount up to about 0.5% antimony.

5. A lead cable sheath containing about 0.002% to about 0.01% lithium, about 0.15% to about 0.18% cadmium, and a minor amount up to about 0.5% antimony.

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