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LEAD ALLOY FOR CABLE SHEATHS

George M. Bouton, Lynbrook, N. Y., and Earle E. Schumacher, Maplewood, N. J., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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This invention relates to lead alloys and particularly to lead alloys suitable for cable sheath.

One of the most extensively used cable sheath alloys is composed of lead and 1 per cent antimony. Much of the strength of this alloy is produced by the process commonly known as precipitation hardening. Under the temperature conditions normally used in the manufacture of cable sheath the antimony present in the alloy is substantially all in solid solution. During cooling and subsequent aging of the sheath at ordinary atmospheric temperatures the antimony precipitates from solid solution since at this lower temperature only about $\frac{1}{4}$ per cent antimony is soluble in lead. On hot summer days the sheath may reach a temperature as high as 48° C. (118° F.) and under these conditions as much as .30 per cent antimony is soluble in lead. The precipitated antimony being highly dispersed throughout the alloy causes a definite increase in strength. It is generally believed by persons skilled in the art that these precipitated particles interfere with slip along the slip or glide planes of the metallic crystals. If the degree of dispersion produced by controlled manufacturing conditions and subsequent aging could be stabilized this alloy would function better under various conditions and would give more satisfactory service than it now does.

The lead 1 per cent antimony alloy, however, is not stable under all conditions of field service. In common with most precipitation hardening alloys the degree of strengthening is dependent on the dispersion of the precipitated phase. Antimony can diffuse in solid lead at ordinary atmospheric temperatures and through this process the particles of antimony gradually coalesce until collectively they are far less effective in preventing slip along the slip planes of the alloy since as they increase in size they decrease in number and leave more and more of the slip planes unstrengthened. As a result of this process a time occurs in the life of the 1 per cent antimony-lead alloy where the increase in the number of particles formed by precipitation is insufficient to offset the decrease in number caused by diffusion and coalescence. From this time on, the strength of the alloy decreases with age. This loss of strength, however, probably is not in itself seriously detrimental to the sheath. However, under certain conditions the process just described can result in serious damage to the cable sheath and cause high maintenance expenses. If the lead-antimony alloy is cold worked, such as by being bent, stretched or in-

dented, the regions of the alloy that have been plastically deformed recrystallize and during this process the antimony is very mobile since precipitation, diffusion, and agglomeration or coalescence take place at tremendously accelerated rates. If the cold working is slight, such as might be produced by mild bending, usually only the edges of the grains of the alloy are deformed as they slide over each other and possibly rotate slightly as they assume positions more favorable to resist the distorting forces. In material treated in this manner only the deformed edges of the grains recrystallize. As described above, the recrystallized material is considerably weaker than the unrecrystallized portions of the grains. The resulting structure thus consists of dispersion hardened grains embedded in or surrounded by a matrix of soft solid solution in which most of the antimony in excess of the amount soluble at atmospheric temperature is present as a few large particles and is therefore relatively ineffective as a hardening medium. When such a structure is stressed, as occurs in aerial cable sheath as a result of temperature variations, all of the resulting deformation is concentrated in the soft matrix. This promotes early failure. In the case of severe deformation of the cable sheath, such as an indentation caused by a blow or by overloaded cable rings, entire grains or groups of grains may undergo recrystallization and consequent softening. When the cable containing this irregularity is stressed the deformation which should be distributed over a considerable length of sheath is concentrated in the recrystallized section and early failure may be expected here.

We have discovered that if the amount of antimony used is restricted to that which can be held in solid solution at ordinary atmospheric temperatures, we can produce an alloy whose essential properties approach those of the lead 1 per cent antimony cable sheath alloy and which is, as far as we have been able to determine, stable throughout its entire life. Such an alloy, since there are no free particles of antimony permanently suspended therein, is homogeneous and hence stresses and strains do not become localized and cause concentration of working at particular spots. In fact, should a sheath of this new solid solution composition be deformed, such as by a blow from a hard object, work hardening would render the damaged area slightly stronger than the surrounding sheath and minimize further working of the bruise.

We have discovered that by adding to lead

just sufficient antimony to produce a true solid solution at ordinary temperatures we can produce an alloy perhaps not as hard as the 1 per cent antimony alloy but still far stronger than pure lead. Such an alloy has great toughness and other beneficial essential properties which make it highly satisfactory for use as sheath on cables suspended aerially and which are subjected to alternating stresses of various frequencies and magnitudes.

We have discovered that a homogeneous, stable alloy of lead with $\frac{1}{4}$ of 1 per cent antimony has a tensile strength of from 2200 to 2400 pounds per square inch as compared with 1600 to 1900 pounds per square inch for unalloyed lead and 2600 to 3000 pounds per square inch for a lead 1 per cent antimony cable sheath. While the latter material may have a strength of as much as 3600 pounds per square inch at the peak of the aging process, it will nevertheless drop back in time to a value not much in excess of that of the new solid solution alloy. These figures represent the strength that may be expected when the respective materials are extruded as cable sheath in the normal manner and are not to be compared with values obtained when the materials are prepared or heat treated in some other manner when they are to be used for some other purpose.

It is known that the quantity of antimony that can be added to lead without exceeding the limit of solubility at ordinary temperatures varies with the purity of the lead used. It is intended that this new alloy may be made using any of the common grades of purity of commercial lead. As an example of what is known as primary lead the tentative specifications for pig lead designation B25-34T set by the American Society for Testing Materials and published by this society under the title "Book of A. S. T. M. Standards" is herein referred to. Any one of the three grades therein specified and known as Grade I Corroding Lead, Grade II Chemical Lead and Grade III Common Lead when alloyed with antimony so that there will be no uncombined antimony in excess of the solid solubility limit at maximum atmospheric temperatures is to be regarded as within the limits of the present invention.

As another example of commercial lead, a common grade is known to the trade as "ninety-

nine and a half," and is generally of secondary origin. This commercial lead which may contain up to .25 per cent bismuth, .10 per cent tin, .10 per cent copper and .02 per cent silver, either singly or combined, when alloyed with antimony so that there will be no uncombined antimony in excess of the solid solubility limit at maximum atmospheric temperatures is also to be regarded as within the limits of the present invention.

Since it is recognized that some of the impurities normally present in commercial lead combine with antimony to form intermetallic compounds, the antimony so combined must not be confused with free antimony in excess of the solid solubility limit. The present invention contemplates a lead-antimony alloy made from any standard grade of commercial lead with the single proviso that the antimony shall not be present in free uncombined form.

What is claimed is:

1. An alloy consisting of 99.75 per cent lead and .25 per cent antimony.
2. An alloy consisting of a saturated solid solution of antimony in lead.
3. An alloy consisting of 99.75 per cent commercial lead and .25 per cent commercial antimony.
4. A cable sheath made of a lead-antimony alloy which is made from lead containing up to .25 per cent bismuth, .10 per cent tin, .10 per cent copper, .02 per cent silver, either singly or combined and up to but not more uncombined antimony than can be held in solid solution at maximum atmospheric temperatures.
5. A cable sheath made of an alloy consisting of 99.75 per cent lead and .25 per cent antimony.
6. A cable sheath made of a lead-antimony alloy which is made from lead containing the usual impurities of commercial standards of lead and uncombined antimony up to but not more than can be held in solid solution at maximum atmospheric temperatures.
7. A cable sheath made of a single phase homogeneous alloy consisting of a solid solution of antimony in lead approaching but not exceeding saturation at ordinary atmospheric temperatures.

GEORGE M. BOUTON.
EARLE E. SCHUMACHER.